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Dimensions of 16-Mm Film

Metol Developer Solutions

Reaction to Video Crosstalk

Independent Frame

Magnetic Sound on 16-Mm Film

Photographic Instrumentation in 1950

Further Screen Brightness Theater Survey

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Dimensions of 16-Mm Film in Exchanges

By A. C. ROBERTSON

A survey has been made of the width, variation in width, and shrinkage of 16-mm film in a number of exchanges. These data are of use to designers of 16-mm equipment in describing the dimensions of film currently being used, and to purchasers of film in giving them some idea of the steadiness characteristics the film might possess.

THE PRESENT USE of 16-mm motion picture film as a professional medium requires that it give the best possible picture quality. The film must be manufactured carefully and handled equally carefully in each subsequent step in order to assure optimum performance. When this film is projected for large audiences, the magnification often is greater than that used for 35-mm film; therefore, for equal steadiness, the dimensional requirements are very severe. A new and exacting field of use is that of television broadcasting.

This paper is concerned with the dimensional characteristics of 16-mm film, particularly the width, variation in width, and to some extent, the shrinkage. Variations in width are often connected with comments about lateral unsteadiness of television images in programs using motion picture film for their subject matter. More often than not, this trouble is associated with 16-mm film made by slitting 32-mm film after processing. Since it was known in the beginning when Debrie introduced the use of 32-mm film, that the slitting after processing might be inaccurate, 32-mm film was made narrower than two strips of 16-mm films.[1] In fact, the first film was 1.252 in. in width and allowed about 0.005 in. for variation in slitting. This allowance was decreased to 0.001 in. later.

The exact magnitude of the slitting irregularities and their effects on the projected image have frequently been discussed, particularly in connection with the choice of the side of the film which is to be used in guiding in the picture aperture. Most of the discussions have been qualitative only, and the purpose of this report is to give as many definite measurements as possible in order to assist the formation of sound judgments in future discussions.

Presented on October 17, 1951, at the Society's Convention in Hollywood, by A. C. Robertson, Manufacturing Experiments Div., Eastman Kodak Co., Kodak Park Works, Rochester 4, N.Y.

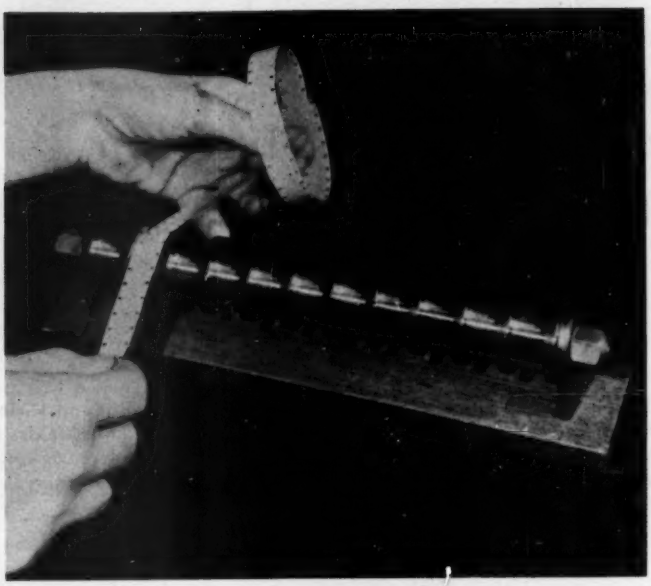

Fig. 1. Width gauge for use in the field.

Fig. 2. Width gauge for use in factory.

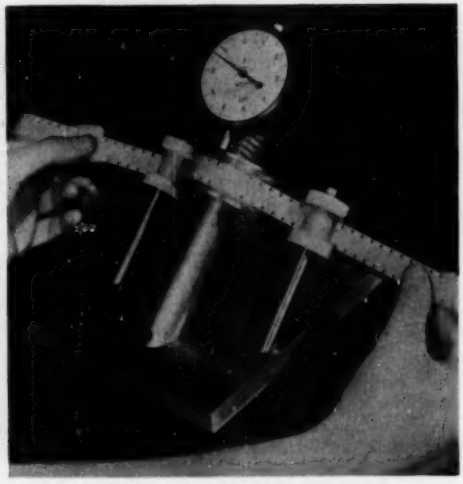

Fig. 3. Dial-indicator gauge for rapid measuring.

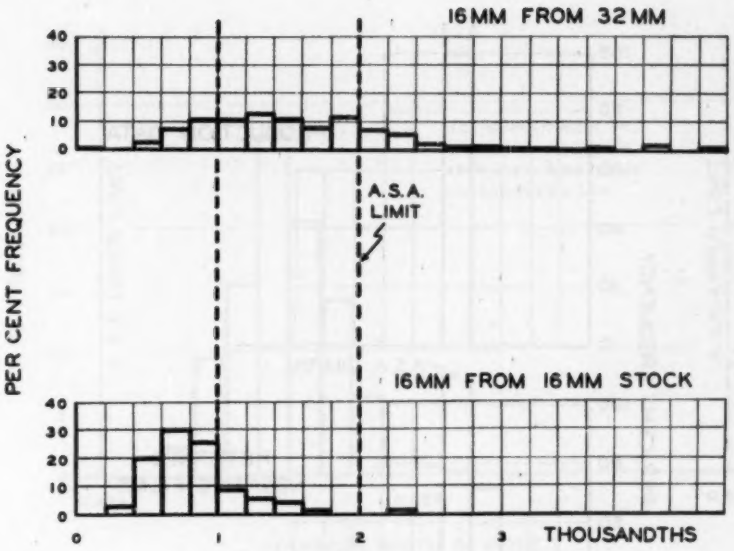

Fig. 4. Variations in width.

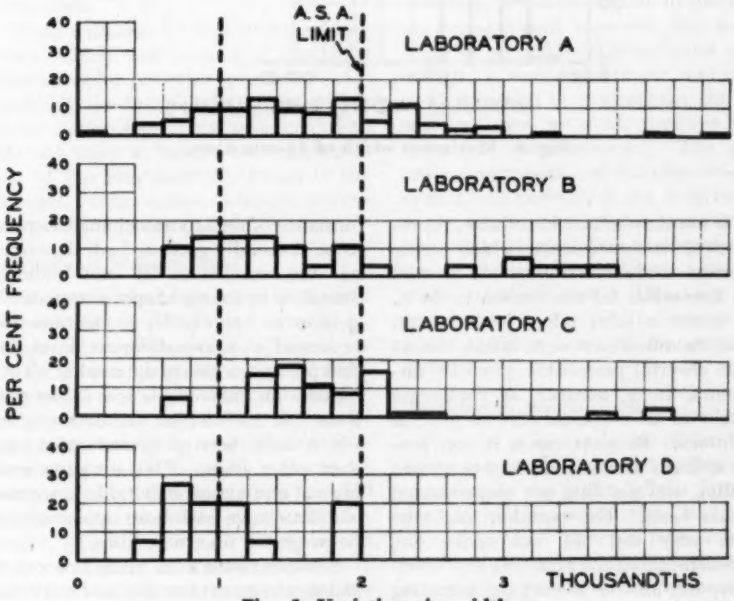

Fig. 5. Variations in width.

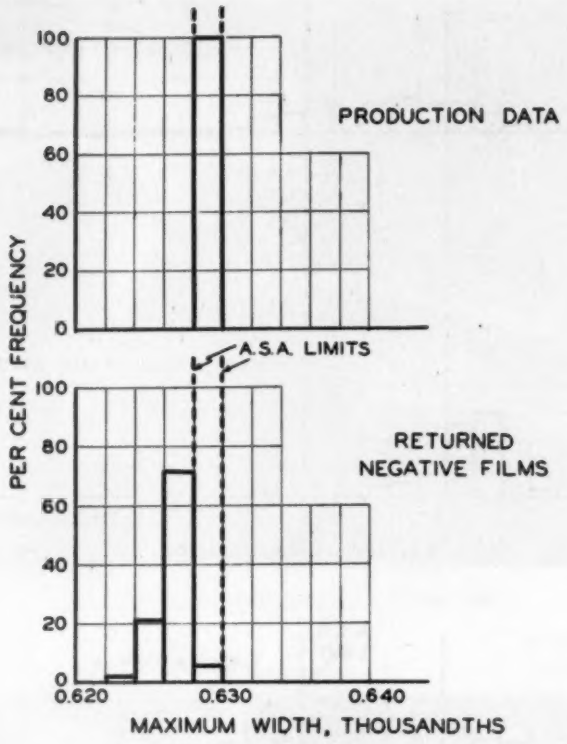

Fig. 6. Maximum width of 16-mm films.

It is not easy to obtain reliable, representative, measurements which truly represent trade conditions. It is well nigh impossible for one person to do it, and hence a joint effort is necessary. These measurements were taken, thanks to the cheerful permission given by distributors, in a number of exchanges thought to be representative of general conditions. In most cases, it was possible to learn which laboratory processed the film, and the data are also reported on that basis. The question might be asked—why did we not make the measurements at the laboratories? Naturally, the answer is that the sampling would give misleading results. The performance of the laboratory might appear to be unusually good or bad, depending on the conditions of the moment. Sampling at the exchanges automatically gave us an opportunity to examine films processed at many different dates, and thus prevents a bias in the results. There remains an unfavorable bias in the data, if one will call it a bias, to have some films which have been projected more often than other films. This situation seems normal and almost inevitable, since most old films have had more opportunity to be projected than new films.

Measurements were made in seven exchanges in recent months, and were combined with data obtained in seven other

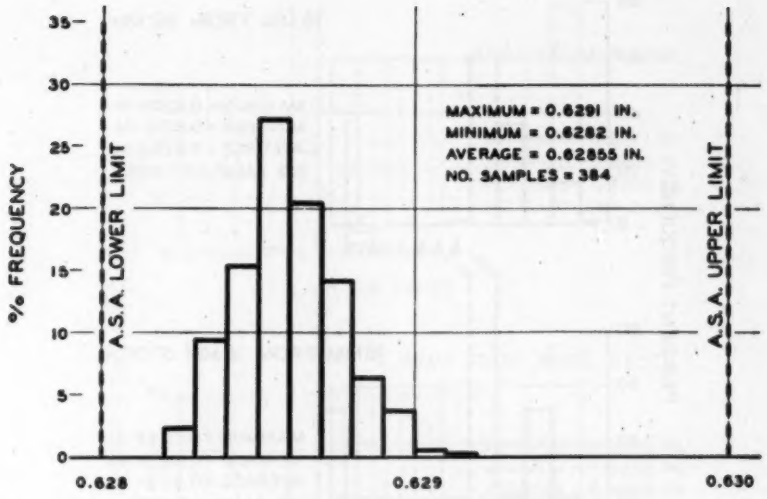

Fig. 7. Maximum width of 16-mm film, slit in Kodak Park, November, 1950.

exchanges during the period covering 1945–1950.

These data may be used for design purposes, which will include a choice of dimensions for projector sprockets.[2] Accordingly, the data on film shrinkages collected during the survey are included so one can have at hand data representative of the film currently found in exchanges. One easily available survey describes conditions in 1938.[3]

Methods of Measurement

Information bearing on troubles caused by wide film is obtainable directly by simple measurements. In Fig. 1 is shown a width gauge for use in the field. It is simply a series of "go" and "no-go" gauges, and is often called a "spool" gauge because of its resemblance to a number of spools on a stick. It can be used to measure film from 0.620 to 0.630 in. in steps of 0.001 in. A similar, larger, gauge for use in the factory is shown in Fig. 2. It measures by steps of 0.0005 in., which values can be further divided by the sense of touch. These gauges have solid hard surfaces and, therefore, are most reliable in determining actual width; however, they are not rapid in use. The dial-indicator gauge in Fig. 3 is more rapid in use, and is particularly useful in determining the periodic variation in width that we sometimes call "drunkenness." The gauge has moving parts and therefore must be maintained carefully if one is to be sure of the exact value of the maximum or minimum width. This requirement demands regular checking with a carefully made standard ring. Also, one must guard against wear, which forms grooves where the film bears on the measuring surfaces.

Variation in Width of Film

Now let us look at some of the results of the survey. It is generally felt that a variation in the width of the film in a regular, cyclic pattern, gives bad results on the screen. There is lateral motion which is soon recognized by the viewer, who soon begins to follow the motion to the disadvantage of the show.

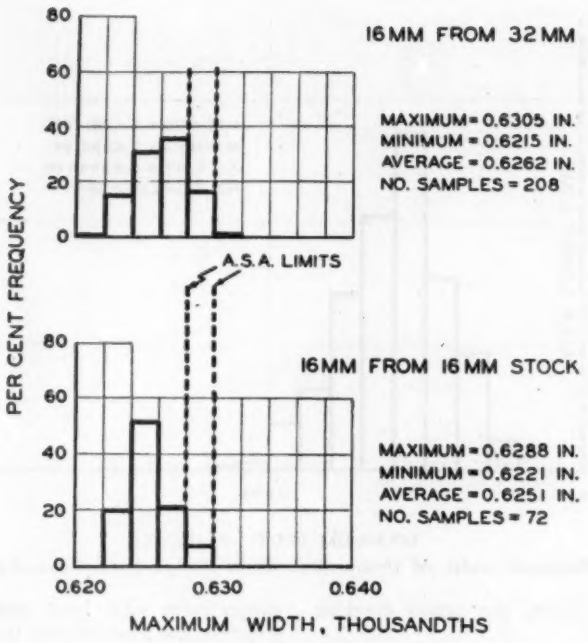

Fig. 8. Maximum widths.

The effect of cyclic variation in width of the film upon projection quality is not as easy to measure as the effect of some other defects. It was obviously impractical to rate the films examined in the exchanges for projection steadiness by jury, much less by our steadiness meter; therefore, we had to judge the quality of this film by the available mechanical measurements, although we know that under some circumstances apparently nonuniform film can give uniform, i.e., steady results, if conditions can be arranged so as to secure "cancellation" of errors.

The cancellation of errors by use of exactly identical design of corresponding parts in the equipment used for taking and projecting amateur films is well understood by a number of people but has not been widely discussed, probably because it has been taken for granted by the few people involved. The effect of cancellation is appreciable. Actually it is easier to show and to explain cancellation in the case of vertical unsteadiness than it is for the case of the lateral unsteadiness discussed thus far. In the case of vertical unsteadiness the conditions for cancellation are satisfied when the projector has the claw-to-aperture[4] distance the same as this relationship in the camera. This demonstration is easiest to make and to explain with films which are camera originals but it can also be done with prints. Robert P. Shea gave an interesting discussion of the complications introduced in making optical prints in his talk presented before the Society at the 1950 Lake Placid meeting.

In general, "cancellation" cannot be depended upon, considering the industry as a whole, because it depends upon making camera, printer, if any, and pro-

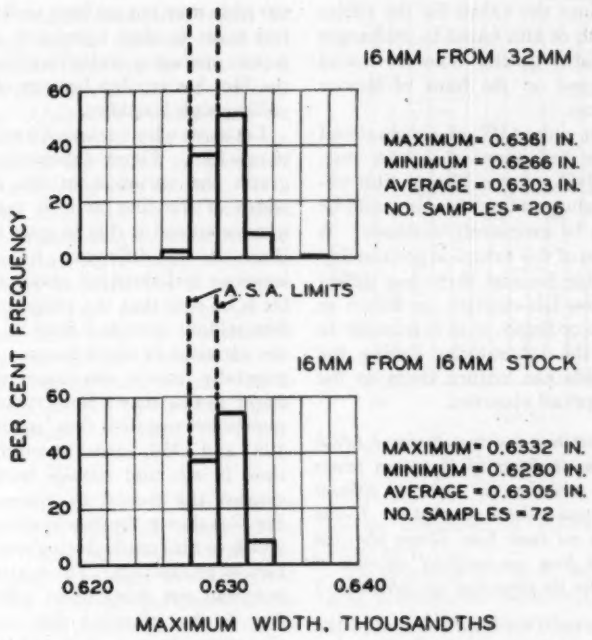

Fig. 9. Adjusted widths at 90% relative humidity.

jector essentially the same in detailed design. There are so many units (and so many conditions) present in the trade at the present time that conditions do not allow cancellation through identical design. Therefore we feel, in general, that nonuniform film will give unsteady images on the screen. In passing, it is worth noting that some people feel that it is improvident to drop all ideas of using cancellation in professional production and are suggesting the subject as a possible topic for standardization.

To return: Figure 4 shows the variation in width of 16-mm film including all the measurements which were made. The upper diagram shows the variation for 16-mm made from 32-mm film and the lower one the variation for film of our manufacture made as 16-mm. For best results the variation in width should be small, that is, the values should fall at the left of the diagram. For some time Kodak 32-mm positive film has carried a dot after the word "Safety" in the legend "Kodak Safety•Positive" in order to identify its kind.

The dotted vertical line on the right part of the graph is set at 0.0020 in. and represents the most liberal interpretation of the ASA specifications. We know this value is too great. Very few people seeing film which is as unsteady as this, for the second time, will agree that it possesses desirable qualities. The line on the left at 0.0010-in. variation seems to constitute a useful compromise as a tolerable limit for lateral movement, though values as low as 0.0008 in. have been recommended.[5,6] Twenty-one per cent of conventional film exceeds the 0.001-in. limit, as does 79% of the 16-mm film made from 32-mm film. Some of the variations in width seem to come from

handling, since the values for the variation in width of film found in exchanges are appreciably greater than we would have predicted on the basis of factory measurements.

Note that only 1½% of conventional 16-mm film lies above the ASA line. However, 24% of the 32-mm film exceeds this value, and much of it would be expected to be excessively unsteady. A good portion of this variation presumably is controllable because there is a difference between laboratories, as shown in Fig. 5. Accordingly, it is reasonable to hope that the laboratories having the wider spreads can reduce them to the narrowest spread observed.

(*A demonstration reel was projected which showed the unsteadiness of the screen image produced by variations in width of different extents. It was pointed out that the 16-mm pictures were not made from 32-mm film, but were selected from an unofficial museum of defects kept for the purpose of eye calibration.*)

A certain need for improvement in the dimensions and consequently the behavior of some 16-mm film made by the 32-mm process is made clear by these measurements. The procedure by which improvement is to be obtained is not so clear. Proposals have been made to the Standards Committee of the Society for a standard describing 16-mm film made by the 32-mm process. The proposal was not entertained because most of the members of the Standards Committee felt that it did not matter how the film was made. Indeed the user need not, and may not, know how the film is produced; therefore, the film should meet the appropriate ASA specifications. In view of the fact that this specification is lenient, it actually devolves upon the purchaser to assure himself that the film is as good as he bargained for.

Maximum Width of Film

The maximum width of the film is a dimension of interest.[7] Film which is too wide may not perform well in projectors made to close tolerances, or in projectors operating under conditions where the film has swollen because of the prevailing high humidity.

Let us see what variation is encountered in raw film. Figure 6 shows in the upper graph the variation in the maximum width of the film as it is made. The narrow spread is due in part to the fact there is no difference in age. Lest someone feel skeptical about the graph, let it be said that the range in width of film seldom exceeds 0.0010 in., and that the variation in width for any one strip is generally much less than that. The lower graph shows how various lots of unexposed negative film, made between 1941 and 1950, varied in width. Variations in age and storage conditions increased the spread in dimensions. In Fig. 7 is shown the distribution of the slit width of film made during one month of factory production. The horizontal scale is spread out thirty times wider than in Fig. 6, thus showing that there is the Gaussian, theoretical distribution shape that one expects.

In Fig. 8 the upper chart shows the maximum width of 16-mm film made from 32-mm film. The lower chart shows the width of 16-mm film made from 16-mm factory-slit film. The amount of oversized 16-mm film made from 32-mm film is small, but real. This is a quantity which should be taken into consideration when designing equipment which is to operate with all available films and under all conditions, including those of high relative humidity.

Figure 9 shows what we think the width of the films of Fig. 7 would have been when freshly processed and conditioned to 90% relative humidity. The first correction was made by estimating what the width after processing would have been, from the shrinkage values observed in the exchanges. This value was then further increased by the appropriate amount to give the effect of conditioning to 90% relative humidity.

This high relative humidity would be encountered only in extreme cases, but these cases are believed to exist often enough so that they should receive consideration. Under these conditions the film is wide enough so that trouble can be expected if the effects of moisture[8] have not been taken into account.

Note that more than half of the films are oversized according to ASA specifications under conditions where 90% relative humidity prevails. It is not possible to guess what percentage of the films would cause jams, but it is possible to see that the spread of values for the 16-mm film made from 32-mm film is greater than for the 16-mm film made from 16-mm stock.

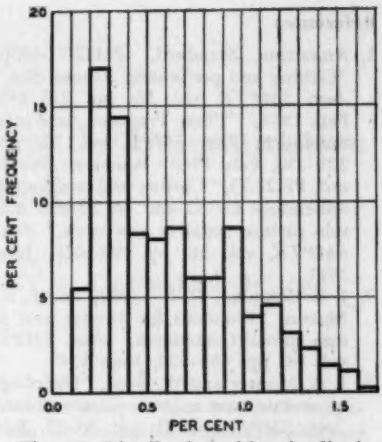

Fig. 10. Distribution of longitudinal shrinkage.

Shrinkage of Film

The longitudinal pitch of film found in exchanges, or its shrinkage, is generally a matter of more importance to the designer of projectors than to the current user or the original purchaser. The pitch is generally affected very little by the operations of the processing laboratory. It is true that some processing equipment, which uses high tensions, can stretch the film put through it by about 0.05%. This value is negligible compared to the changes in length that come with time.

Figure 10 shows the distribution of longitudinal shrinkage for all films measured in the exchanges. Note that there is no film with a shrinkage over 1.7%. To design sprockets for film of greater shrinkage than this will generally give sprocket teeth that are quite thin if there are many teeth in contact with the film. If a design value as small as 1.5% is adopted, then there is a chance of about one in sixty that the perforations in some film will interfere with the sprockets and be damaged. Actually, the choice of longitudinal dimensions is also affected somewhat by the local deformation around the edge of the perforation. This deformation is caused by tension put on the film by the sprockets, a matter discussed by Vilbrandt[9] several years ago.

By referring to Fig. 8, we ought to be able to obtain the narrowest (maximum) width of film measured in the survey. Actually 0.6215 in. was the lower range of the gauge, and so we could not read smaller values. There were 1½% of film in the class 0.620 in. to 0.622 in. Accordingly, the uncertainty is not a great one, and indeed not a vital one. In general, if a 16-mm projector is designed for wider film than that used, little harm will be done to the film. There will be no tearing of perforations as is the case when the longitudinal pitch is below the design value, though sound-track placement will be affected. Sound-track placement was not measured in this survey. It may be expected that the errors of placement would be about the same as those of centering the film in slitting and would show a fluctuation about as great as the variation in width.

Thanks are due to those in the industry who made possible this survey and particularly to Daniel Botkin and Eldon Moyer of our division for their care in taking many measurements and reducing the data to useful form.

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Use of Glacial Acetic Acid in the Determination of Metol in Developer Solutions

By WILLIAM R. CROWELL, HARVEY E. GAUSMAN, Jr., and HARLAN L. BAUMBACH

Although metol behaves as a very weak base in aqueous solutions, it acts as a strong base in glacial acetic acid and can be titrated with glacial acetic acid solutions of perchloric and sulfuric acids, using an indicator. The end point is much sharper with perchloric acid than with sulfuric acid as shown by potentiometric titration curves of the two acids. Procedures and results are described for the analysis of several types of developer solutions employing glacial acetic acid solutions for the metol determination and ceric sulfate for the determination of hydroquinone.

Conant and Hall,[1] Hall and Werner,[2] Nadeau and Branchen[3] and recently Markunas and Riddick[4] have shown how bases very weak in aqueous solutions can be titrated as strong bases in glacial acetic acid solutions. In a recent note Idelson[5] has suggested that glacial acetic acid can be used as a medium for the determination of metol in developer solutions. It is the purpose of this paper: to show how this method can be applied to the determination of metol in developer solutions using an indicator without the necessity of a potentiometric titration; to compare titrations made with perchloric acid with those made with sulfuric acid; and to show how hydroquinone may be determined by titration with ceric sulfate of the solution in which the metol had previously been determined.

A contribution submitted August 27, 1951, by William R. Crowell, Dept. of Chemistry, University of California at Los Angeles, Los Angeles, Calif., and Harvey E. Gausman, Jr., and Harlan L. Baumbach, Paramount Pictures, Inc., Hollywood, Calif.

Preparation and Standardization of Acid Solutions

First, prepare a standard sodium acetate solution by weighing out sufficient dry sodium carbonate to make an approximately 0.0500 *N* solution in the volume desired. Add this solid to a somewhat less volume of 99.5% glacial acetic acid, dissolve, and make up to volume. Prepare an approximately 0.0500 *N* solution of perchloric acid from the 70–72% reagent by weighing out the proper amount and making it up to volume by the addition of glacial acetic acid. In the same manner a 0.0500 *N* solution of sulfuric acid may be prepared from the concentrated acid.

All these reagents should be stored in glass containers provided with airtight

glass stoppers. The titrations can be performed with 5-ml microburets with glass-stoppered reservoirs, side arms and two-way stopcocks. During titrations calcium chloride drying tubes should be attached to the reservoir opening and to the top of the buret tube. When the burets are not in use the reservoir drying tube may be replaced by the glass stopper and the connections of the drying tube attached to the buret tube may be closed off by suitable pinch clamps.

To standardize the acid, deliver into a 125-ml Erlenmeyer flask 50 ml of glacial acetic acid, 30 ml of ethyl acetate, 2–4 ml of the standard sodium acetate solution, and three drops of crystal violet indicator consisting of a 0.2% solution in glacial acetic acid. Titrate with the acid to the point at which the reddish violet of the base changes to a blue or greenish blue. The perchloric acid end point is quite sharp and only a fairly good light is necessary, but sulfuric acid requires good illumination such as that furnished by a Fisher Illuminator, and a comparison solution will probably be necessary, at least until one becomes accustomed to the end-point change. The comparison solution may be that resulting from a previous preliminary titration, or a $KHSO_4$ solution in the glacial acetic acid–ethyl acetate indicator mixture. For each acid a blank correction should be made in the volume of acid required. This may be determined by adding the acid to a mixture containing the same amounts of glacial acetic acid, ethyl acetate and indicator until the color matches that of the comparison solution.

For practical purposes in the analysis of developer solutions it is not necessary that the glacial acetic acid solutions be strictly anhydrous. The small amounts of water in the glacial acetic acid itself, as well as that liberated in dissolving the sodium carbonate and that contained in the concentrated perchloric and sulfuric acids, is not sufficient to affect seriously the sharpness of the end points.

Orange IV (tropaeolin 00) was also found to be a very satisfactory indicator, the color change being from yellow or orange-yellow to pink.

In the standardization of sulfuric acid solutions it should be remembered that the equivalent weight of the acid is equal to its molecular weight. Evidently only the first stage of ionization of the acid is sufficient to give a satisfactory end-point change and there appears to be no appreciable interference by the second stage.

Determination of Metol

Into a 50-ml separatory funnel pipet 10.0 ml of the developer solution, add two drops of thymol blue indicator and 6 *N* sulfuric acid dropwise until the solution just turns yellow (pH 8.0 to 8.5). Introduce 4–5 grams of potassium bromide and shake until it is dissolved. Add to the funnel 15 ml of ethyl acetate and shake for about three minutes, taking care that there is no loss through the glass stopper of the funnel due to the thermal expansion of the ethyl acetate. Allow the funnel to stand about three minutes or until the layers have separated completely and drain the aqueous layer into a 50-ml beaker, taking care that all the aqueous phase passes out of the stopcock bore. Pour the ethyl acetate layer into a dry 100-ml beaker, and from this to a second and to a third beaker, and finally into a 125-ml Erlenmeyer flask containing 50 ml of glacial acetic acid. Allow any liquid remaining in the stopcock bore of the separatory funnel to drain into the beaker, return the aqueous portion to the funnel, and rinse the beaker with 15 ml more of ethyl acetate, adding this to the funnel. Make a second extraction in the same manner as that made for the first portion, again adding the second extract to the glacial acetic acid.

To the glacial acetic acid mixture add three drops of crystal violet or orange IV indicator solution and titrate with standard acid, following the same procedure as that used in the standardization. The

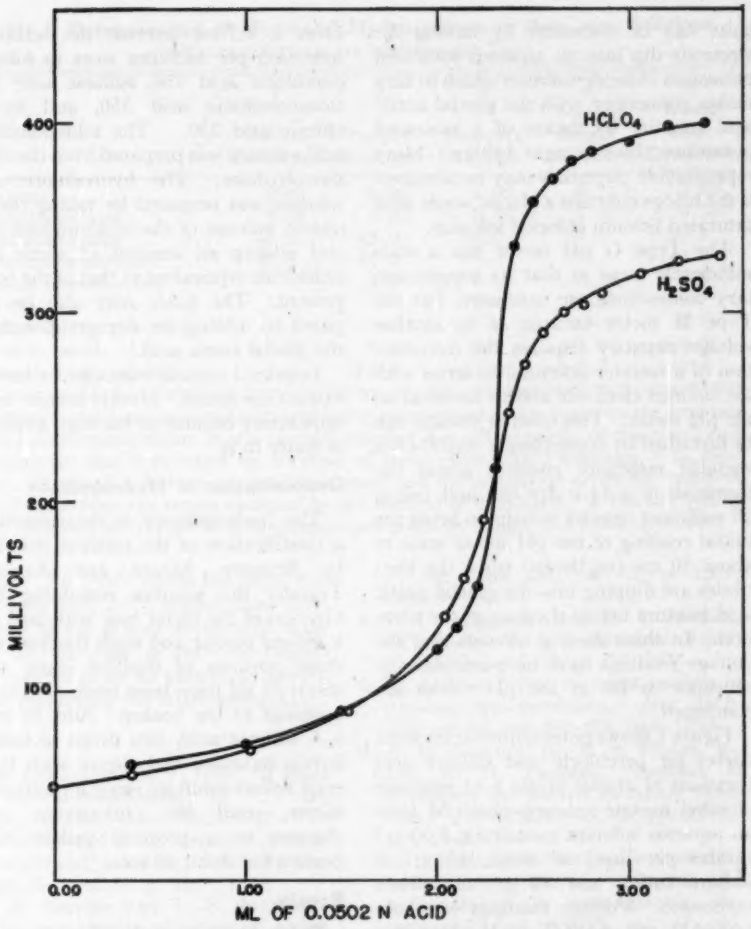

Fig. 1. Titration of metol base in glacial acetic acid.

same comparison solution may be used. The blank correction can be obtained by following the foregoing procedure on a solution with the same composition as the developer except that the metol is omitted.

Potentiometric Titration of Metol Base With Perchloric and Sulfuric Acids

In order to study the end points obtained in the titration of metol base with perchloric and sulfuric acids, potentiometric titrations were carried out on the glacial acetic acid–ethyl acetate mixtures. A Beckman Type G or Type H pH meter employing glass and calomel electrodes can be used to measure the voltages. If a Beckman saturated calomel electrode is used for a large number of runs, it should not dip directly into the glacial acetic acid mixture as it might eventually cease to function. This diffi-

culty can be overcome by having the electrode dip into an aqueous saturated potassium chloride solution which in turn makes connection with the glacial acetic acid mixture by means of a saturated potassium chloride agar bridge. More reproducible potentials may be obtained if the bridge contains a glacial acetic acid saturated lithium chloride solution.

The Type G pH meter has a scale sufficiently large so that no supplementary connections are necessary, but the Type H meter because of its smaller voltage capacity requires the introduction of a counter potential in series with the calomel electrode and its terminal on the pH meter. This counter voltage can be furnished by connecting a 50,000-ohm variable resistance rheostat across the terminals of a 1½-v dry cell and taking off sufficient counter voltage to bring the initial reading of the pH meter scale to about 50 mv (millivolts) when the electrodes are dipping into the glacial acetic acid mixture before the start of the titration. In this case it is obvious that the voltage readings have no particular significance as far as the pH values are concerned.

Figure 1 shows potentiometric titration curves for perchloric and sulfuric acid titrations of glacial acetic acid solutions of ethyl acetate extracts obtained from an aqueous solution containing 2.00 g/l (grams per liter) of metol, 45 g/l of sodium sulfite and 40 g/l of sodium carbonate. Voltage readings were obtained by use of the Type H pH meter. It will be observed that while the perchloric acid inflection is much sharper than that of the sulfuric acid, the latter is quite sharp and the end point should be capable of recognition with an indicator without serious difficulty. Over an interval of 0.2-ml the perchloric acid inflection is about 900 mv/ml, while the sulfuric acid inflection is about 400 mv/ml.

In another series of runs the inflections with perchloric, sulfuric, toluenesulfonic and hydrochloric acids were compared. Over a 0.2-ml interval the millivolts inflection per milliliter were as follows: perchloric acid 950, sulfuric acid 340, toluenesulfonic acid 350, and hydrochloric acid 330. The toluenesulfonic acid solution was prepared from the dried monohydrate. The hydrochloric acid solution was prepared by taking the required volume of the concentrated acid and adding an amount of acetic acid anhydride equivalent to that of the water present. The latter may also be prepared by adding the dry gas directly to the glacial acetic acid.

Isopropyl acetate may also be used to extract the metol. Methyl acetate is not satisfactory because of the high solubility of water in it.

Determination of Hydroquinone

The hydroquinone is determined by a modification of the method described by Brunner, Means and Zappert.[6] Transfer the solution remaining after titration of the metol base with acid into a 250-ml beaker and wash the flask with three portions of distilled water until about 55 ml have been used, adding the washings to the beaker. Add 10 ml of 6 *N* sulfuric acid, two drops of 0.02 *M* ferroin indicator and titrate with 0.1 *N* ceric sulfate solution, using a mechanical stirrer, until the pink-orange color changes to a greenish yellow which persists for about 30 sec.

Results

Table I shows results of analyses carried out on several types of developer solutions, most of which were supplied by the Paramount Pictures laboratory.

The same procedure was applied to an Ansco Color Second Developer for the determination of the diethyl-*p*-phenylenediamine chloride in a solution containing 4.5 g/l of this constituent, 1.0 g/l of sodium bisulfite, 70.0 g/l of sodium carbonate and 2.50 g/l of potassium bromide. Results of the glacial acetic acid titration were 4.42 ± 0.03 g/l and of the ceric sulfate titration 4.52 ±

Table I. Determination of Metol and Hydroquinone in Developer Solutions
(All concentrations are in grams per liter)

	1 Positive Developer	2 Positive Developer	3 Negative Developer	4 Negative Sound Track	5 Ansco First Developer
Metol conc.	2.00	2.06	1.00	0.33	3.50
Hydroquinone conc.	3.50	3.62	0.50	1.80	6.50
Sodium sulfite conc.	45.0	45.0	50.0	50.0	50.0
Sodium carbonate conc.	40.0	40.0	—	—	40.0
Potassium bromide conc.	—	4.0	0.30	0.16	2.0
Borax conc.	—	—	10.0	10.0	—
Potassium thiocyanate conc.	—	—	—	—	2.0
% error in metol	±0.5	0.0	0.0	+3.0	±0.3
% error in hydroquinone	−1.0	+0.3	−2.0	−0.7	−1.4

Developers 1 and 5 are unused developers and percentage errors are based on the amounts of metol and hydroquinone in the samples weighed out. The purity of the metol and hydroquinone was determined by titration of their sulfuric acid solutions with ceric sulfate. Numbers 2, 3 and 4 are used developers and the percentage errors are based on the deviations from the results obtained by the method of Baumbach.[7] The low results usually obtained in the case of hydroquinone are probably largely due to air oxidation.

0.03 g/l. In other words the ceric sulfate results were 2.2% higher than those obtained in the glacial acetic acid titration. In the case of such developers there appears to be no particular advantage in employing the latter method.

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Observer Reaction to Video Crosstalk

By A. D. FOWLER

Presented here are results of tests to determine how much video crosstalk can be tolerated in black-and-white television pictures. Experienced observers viewed a television picture and rated the disturbing effects of controlled amounts of crosstalk from another video system. Crosstalk coupling was simulated by a network which permitted changes in frequency characteristic as well as in coupling loss. Tolerable limits for crosstalk coupling are derived from the test results.

VIDEO CROSSTALK becomes an important consideration when two or more video transmission systems operate on adjacent facilities. If the coupling between systems is excessive, crosstalk from one system will seriously impair the picture transmitted by another. To eliminate crosstalk coupling entirely is usually impracticable, if not impossible; to reduce it by even modest amounts is sometimes difficult and expensive. The question naturally arises as to how much crosstalk can be safely tolerated. To answer this question, a series of tests, similar to those described in a previous paper,[1] was made at Bell Telephone Laboratories. Observers were asked to rate the disturbing effects of various amounts and kinds of crosstalk in a standard black-and-white television picture. The purpose of this paper is to describe those tests and to present the values of crosstalk limits derived from the experimental data.

In all tests artificial crosstalk coupling was used. The disturbing television signal was fed into the disturbed television system through an attenuator and a network: the former controlling the flat coupling loss, and the latter imparting a desired loss-frequency characteristic. This type of coupling is called "lumped" to distinguish it from coupling distributed along transmission lines. The latter comprises components which may have different propagation times. Requirements for lumped coupling are probably somewhat more severe than for distributed coupling.

Four different loss-frequency characteristics were employed. They ranged from flat, which gives an undistorted crosstalk image, to very steeply sloping (less loss at higher frequencies). This range covers most of the general shapes of characteristics found in practice.

Presented on October 15, 1951, at the Society's Convention at Hollywood, Calif., by A. D. Fowler, Bell Telephone Laboratories, Inc., Murray Hill, N.J.

If strong enough, video crosstalk appears as an image of the unwanted signal moving erratically back and forth across the wanted picture. This motion occurs, of course, because of the lack of exact synchronism between independent video systems. Even when both systems are controlled from the same 60-cycle supply, rather violent horizontal motion will be present. This is the result of slight phase errors at 60 cycles/sec producing cycles of phase error at the horizontal scanning rate. In some of the tests, the two systems were placed under the control of separate crystal oscillators. This permitted the relative motion to be made uniform at about the most disturbing rate.

As the crosstalk image moves across the main picture, it appears to be framed. This frame is formed by the horizontal and vertical synchronizing pulses, and is much more noticeable than any feature in the image. Since the side frame of the image extends from top to bottom of the wanted picture, no part of the latter escapes this interference. At threshold there is no semblance of frame or image; just a slight flicker appears as the frame moves across some sensitive portion of the main picture.

The above discussion applies to undistorted, or flat, crosstalk coupling. When the coupling has a sloping characteristic, the crosstalk image will appear in bas relief. But, again, the frame having the largest rate of change, is the most prominent feature in the crosstalk image.

Apparatus and Circuit Arrangement

In Fig. 1 is shown a simplified block schematic of the test setup. The box labelled "slide scanner" represents a conventional flying-spot scanner in which the main picture signal was derived. The slide was a standard 2 × 2-in. slide of a picture called "Teacup Lady." The output signal had an amplitude of 2 volts peak-to-peak (including the synchronizing pulse) and was transmitted via a 3-way mixing pad to the viewing monitor shown on the right. The interfering picture was a test pattern known as "Indian Head." The signal for the test pattern was generated by a monoscope, which is shown in the box with the appropriate label. The output of the monoscope was also 2 volts peak-to-peak, and it was transmitted through a variable attenuator and distorting network to the mixing pad.

Synchronizing signals for the slide scanner and monoscope were obtained from independent generators. These are indicated by separate boxes labelled "sync generator." Both generators were controlled either from the same 60-cycle power source or from separate crystal oscillators.

The viewing monitor was one developed and built at Bell Telephone Laboratories. The picture tube was a 10-in. metal-backed tube (Type 1816 P4) operated at about 11 kilovolts. A d-c restorer circuit of the type usually found in television receivers was used instead of the clamper originally incorporated in the viewing monitor. "Flywheel" synchronization, which this monitor did not have, was simulated by separate synchronization directly from the synchronizing generator associated with the spot scanner.

Since the distorting network had zero loss at 4 mc, or had a loss which could be taken into account, the loss in the attenuator represented the coupling loss at 4 mc as measured between two television systems at points of equal signal level. The coupling loss at other frequencies depends on the characteristic of the distorting network.

Figure 2 shows the four loss-frequency characteristics which were used in the tests. The "flat" characteristic was simply distortionless transmission. The one labelled "6 db/octave" gave an increase in transmission of approximately 6 db for each doubling of frequency. The "12 db/octave" and "26 db/octave" labels have similar meanings. The last-named characteristic approxi-

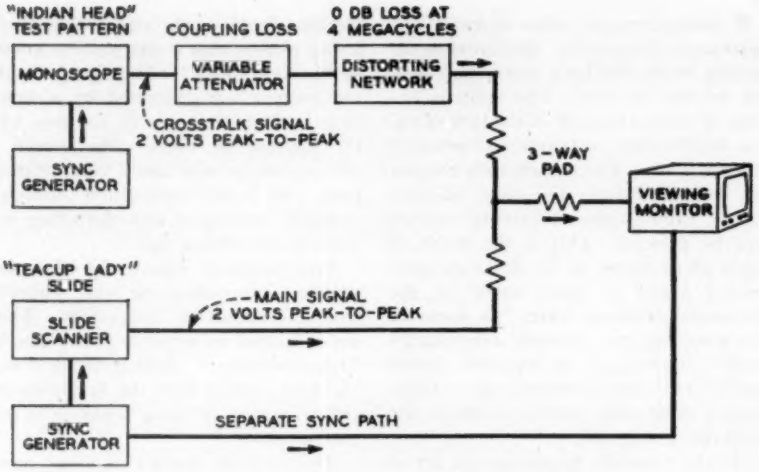

Fig. 1. Block schematic of test setup.

mates the amplitude-frequency distortion (without propagation effects) occurring in near-end crosstalk between video systems operating in local exchange areas on maximum length of line.[2]

Picture Setup and Viewing Conditions

The selection of "Teacup Lady" as the main picture for these tests was based on past experience. Its sensitivity to noise and low-frequency interference had already been established. During all tests a highlight luminance of 45 foot-Lamberts and a contrast range of 120:1 were maintained. Frequent checks on these values were made with a modified Macbeth Illuminometer.

The "Indian Head" test pattern was chosen as the interfering picture because of its high key and strong black lines. Its sudden changes from white to black tend to make its distorted image more interfering than that of most pictures.

All viewing was done in a darkened room in which the ambient light, resulting mostly from light reflected from the kinescope, was approximately 0.02 foot-candles as measured near the viewing surface.

The viewing distance was 24 in. which was four times the height of the 6 × 8-in. image.

Observers

Observers for these tests were technical and staff employees of Bell Telephone Laboratories. In each test group there were ten or more observers, some of whom were known to be rather critical, that is, intolerant of picture impairments, some less critical, and others fairly uncritical. All were experienced and were known to be reasonably stable in their judgments. They were selected on the basis of giving a fairly uniform distribution of types of observers ranging from critical to uncritical. No attempt was made to obtain a random sample of the television audience.

Testing Procedure

One observer at a time was seated directly in front of the viewing monitor at a distance of four times the picture height. The room was darkened and the observer was shown the main picture, "Teacup Lady," without any crosstalk signal added. He was told that this was the "best" picture, and that any

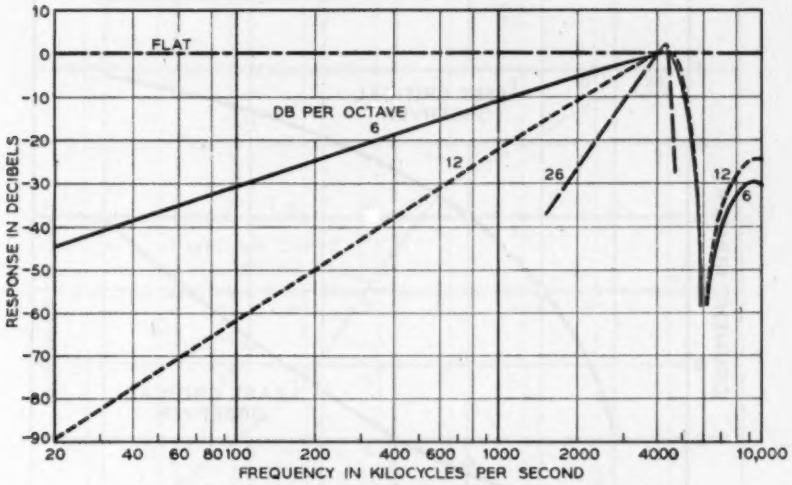

Fig. 2. Amplitude-frequency distortion in crosstalk paths.

imperfections, such as noise and the like, were to be ignored in making his subsequent judgments of picture impairments. A moderate, but visible amount of crosstalk signal was then added to the picture. The observer was told that this was the type of disturbance upon which he would be asked to pass judgment, but that the strength of the interference would probably be different for each test condition.

The observer was given a list of seven numbered comments from which he was to select the one which best described his reaction to, or his rating of, the crosstalk present in each test condition. These comments were as follows:

1. Not perceptible;
2. Just perceptible;
3. Definitely perceptible, but only slight impairment to picture;
4. Impairment to picture, but not objectionable;
5. Somewhat objectionable;
6. Definitely objectionable; and
7. Extremely objectionable

The comments are arranged in logical order, progressing step by step from "not perceptible" to "just perceptible" through various degrees of adverse reaction to "extremely objectionable." The comment numbers are used, not only as indentifications of the various comments, but also as a scale of observer reactions. Special mention will be made in later discussions of comments No. 2 and No. 4: the former signifies the near threshold value of crosstalk for the observer; the latter is the severest comment which can be made without rating the crosstalk as objectionable.

At each sitting, the observer rated from 16 to 22 levels of crosstalk. The levels covered a range of 28 db, subdivided into 4-db steps. Each level appeared twice, and in some tests, three times in the series. All observers were shown precisely the same series of levels. The presentation of levels was in random order; use of Tippett's *Random Sampling Numbers*[3] was made for this purpose.

As each test condition was presented, the observer called out the number of the comment which best described his reaction to the level of crosstalk present. Separate tests were made for each type of distorting network in the crosstalk coupling path.

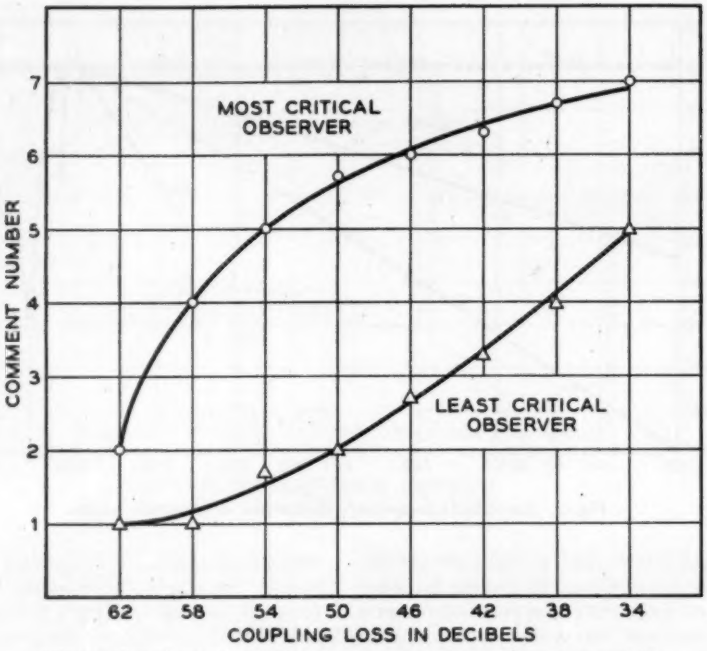

Fig. 3. Reactions of individual observers to flat, lumped crosstalk.

Test Results and Interpretation of the Data

Observers apparently use the comment numbers as a scale of their reactions. This will be seen in Fig. 3 where, for purposes of illustration, are plotted the reactions of only two observers to flat, lumped crosstalk. The flat coupling loss is given by the abscissas which indicate stronger crosstalk to the right; comment numbers are indicated by the ordinates. The data points shown are the averages of three judgments of the same indicated crosstalk level submitted to the observer. Only in rare instances did an observer waver by more than one comment in rendering his judgment of a given level of crosstalk. The curves for other observers, in general, fan out between the two curves shown. Occasionally, however, some of the curves cross. This means, for example, that the most critical observer may not be the same observer over the entire range of crosstalk levels. For this reason it was decided to pool the data of all observers and pick out the critical, median and uncritical responses characterizing the reaction of the group. This treatment of the data is illustrated, in part, in Fig. 4.

Figure 4 shows the distribution of the comments selected by the entire group of observers in response to various levels of flat, lumped crosstalk. The numbers at each of the marked lattice points represent the totals of votes cast for the indicated comment number at the given level of crosstalk. In this test 10 observers made three judgments of each level of crosstalk except that for 62-db coupling loss where only one judgment was made. Accordingly, the total of the lattice point numbers is 30 in each column, except that for 62-db, where the

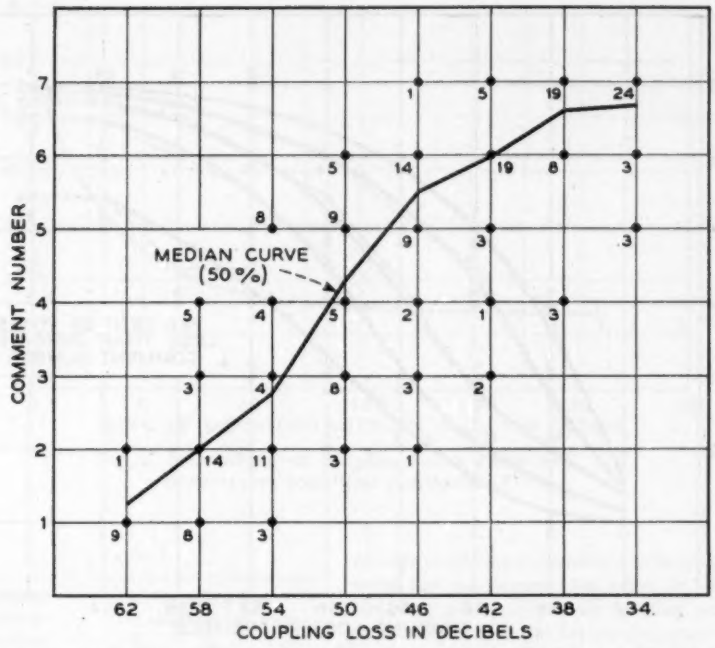

Fig. 4. Distribution of comments from 10 observers (flat, lumped crosstalk).

total is 10. From this display of the data, one can see that when the coupling loss was, say 54 db, there were 3 votes for comment No. 1, 11 for comment No. 2, 4 for No. 3, 4 for No. 4, and 8 votes for No. 5.

The data shown in Fig. 4 can be further classified by drawing in, for example, the curve (or broken line) below and above which 50% of the votes fall. This is shown in Fig. 4 as "median curve." To avoid ambiguities in the count of votes, it was assumed that the votes for each comment were spread uniformly over a range of plus or minus one-half of a comment number; at the ends of the scale, where there could be no comments less than No. 1 or greater than No. 7, the spread was assumed to be only one half as much.

In a similar way, other contours, below which a given percentage of the votes fall, can be drawn. This was done for several different percentages as shown in Fig. 5. These contours pertain to the same group data shown in the previous figure. The computed values are shown as dashed broken lines. The heavier smooth curves were drawn in more or less by eye to show the general trends for engineering purposes. It will be rather evident that the 90% contour corresponds to a curve for a critical observer, the 50% contour to one for a median observer, and the 10% curve to an uncritical observer. As mentioned earlier, these contours do not necessarily represent the reactions of any individual observers.

The contours of Fig. 5 show that a fairly uniform distribution of types of observers was obtained; there is no pronounced bunching of the contours. Looking now at the 90% contour, which

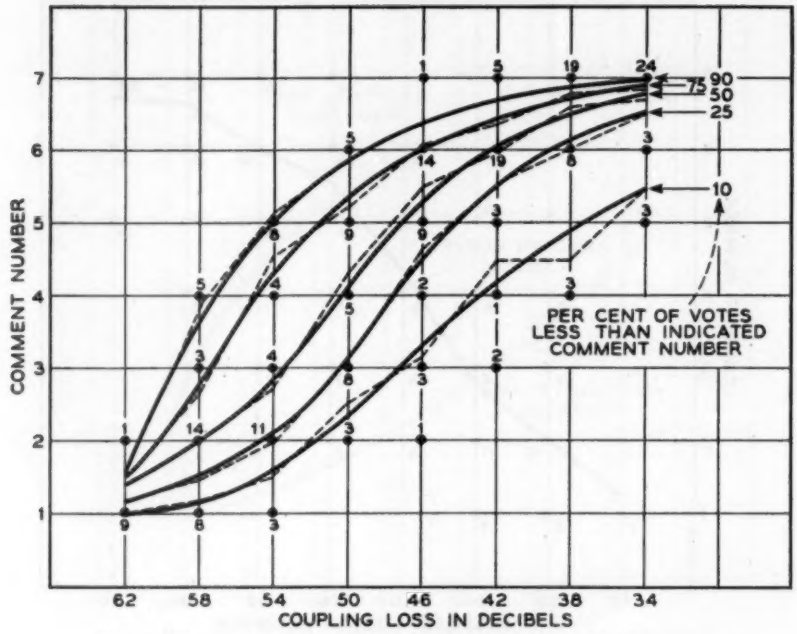

Fig. 5. Distribution contours of comments from 10 observers (flat, lumped crosstalk).

represents the reactions of the "composite" critical observer, it is seen that the crosstalk is just perceptible to him when the coupling loss is about 61 db and that he still does not object to it (votes no more than comment No. 4) when the crosstalk is made 4 db stronger. The median observer finds the crosstalk just perceptible at 58 db loss; and the uncritical observer does not notice the crosstalk until the coupling loss is reduced to 52 db.

One of the main objectives of this study of the reactions of observers to crosstalk was to arrive at a tolerable limit for the crosstalk coupling loss. The contours of observer reaction, as just discussed, will serve as a useful guide in this connection. As a criterion for tolerable limit, it is proposed that the crosstalk not exceed a value which is either objectionable to the most critical observers, or more than just perceptible to half of the observers. Referring to the contours of Fig. 5, it is seen that a coupling loss of 58 db evoked comment No. 2 from 50% of the observers and less than comment No. 4 from the most critical observers. The limiting coupling loss is, accordingly, 58 db for flat, lumped crosstalk.

The test results for the sloping types of coupling and for both synchronous and nonsynchronous operation of the video systems are very similar to those discussed in detail for flat coupling. They differed mainly in the values of coupling loss at which the comments occurred and, to some extent, in the steepness of rise of the contours. Rather than a display of separate matrices and contours for each of the tests, a summary of the responses of the critical and median composite observers is presented in Table I which follows.

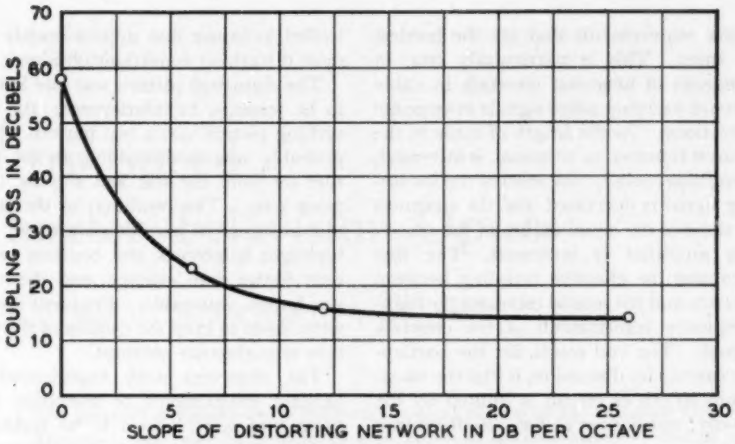

Fig. 6. Four-megacycle coupling loss at which 50% of observers vote "just perceptible."

Table I

Coupling network distortion	Coupling loss, in decibels, at 4 mc		
	A	B	C
Flat* (1)	61	57	58‡
Flat† (2)	60	55	57.5
6 db/octave*	27	22	23‡
12 db/octave*	17.5	10.5	11.5
12 db/octave†	19	14	15.5‡
26 db/octave*	20	12	14‡

Column A: Critical observers rate "just perceptible" (comment No. 2)
Column B: Critical observers rate "impairment to picture, but not objectionable" (comment No. 4)
Column C: Median observers rate "just perceptible" (comment No. 2)

* Nonsynchronous: crosstalk image moves left to right at rate of 2 frames/sec.
† Synchronous: crosstalk image moves erratically back and forth across the main picture.
‡ Selected as the limit for the indicated type of crosstalk coupling.

Discussion of Results

One of the most striking aspects of the results tabulated above is the large change in required coupling loss in going from flat to sloping distortion in the coupling path. Since the sloping network emphasizes the higher frequencies at the expense of the lower, the former must contribute very little to the interfering effect of the crosstalk image. This seems a reasonable conclusion when it is remembered that the high frequencies contribute to fine detail and sharp edges, neither of which is very apparent in the faint and moving crosstalk image.

To show the change in requirement with changes in slope of the coupling characteristic, the values marked ‡ in Table I have been plotted in Fig. 6. Here the abscissas represent the slope of the coupling characteristic in decibels per octave of frequency; the ordinates indicate the required coupling loss in decibels at 4 mc. It will be noted that the major portion of the reduction in requirement takes place within the first 6 db per octave; and that the requirement appears to approach an asymptotic value.

Despite the easing of requirements by as much as 35 to 44 db in going from flat to sloping couplings, it is more often the

latter requirements that are the hardest to meet. This is particularly true in instances of near-end crosstalk in cable circuits carrying video signals in opposite directions. As the length of cable to the nearest repeater, or terminal, is increased, two things occur: the level of the incoming signal is decreased and the steepness of slope of the equalization of the receiving amplifier is increased. The first increases the effective coupling between circuits and the second increases the high-frequency transmission of the crosstalk signal. The end result, for the particular case under discussion, is that the maximum length of circuit is limited by the 14-db requirement for 26-db/octave slope.

The differences between the results for synchronous and nonsynchronous operation are not significantly great. As implied earlier, the term "synchronous" is a misnomer, and actually means erratic motion rather than uniform motion of the crosstalk image. For the flat crosstalk tests the difference was trivial; for the 12-db/octave case a difference of 4 db obtained.

All the above results, it should be noted, were obtained for lumped couplings between circuits carrying the wanted and unwanted picture signals. This results in a reasonably clear unwanted picture, which aids in its detection and imposes rather severe coupling requirements. Where the coupling is distributed over a long distance, as in adjacent pairs, the crosstalk image will be less clear and probably somewhat less severe requirements would be imposed.

Recapitulation

Tests were made to determine how much video crosstalk can safely be tolerated in black-and-white television pictures. Artificial crosstalk coupling with four different loss-frequency characteristics was used. In using lumped, rather than distributed, coupling more conservative requirements were obtained. The degree of synchronization was controlled to insure that approximately the most disturbing conditions obtained.

The disturbed picture was one known to be sensitive to interference; the disturbing picture was a test pattern which probably was as disturbing as any picture for both the flat and sloping coupling tests. The rendition of the main picture received considerable care: the highlight brightness and contrast range were better than average, and the noise was barely noticeable. Frequent checks were made to keep the quality of the picture reproduction constant.

The observers were experienced in judging impairments of television pictures, and were known to be stable in their judgments. The conditions of observation were controlled in the matter of ambient light and viewing distance.

The results obtained from these tests and proposed as limits for the several types of crosstalk coupling are somewhat conservative. The crosstalk resulting from these values of coupling could not be detected by about half the observers and were not rated as objectionable by the most critical.

Acknowledgments

The author acknowledges his indebtedness to H. N. Christopher, who was a close associate in conducting the experiments; to J. M. Barstow, under whose direction the work was done; and to Pierre Mertz, technical advisor to the project, who suggested the testing technique.

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Ultra-Speed Theater Television Optics

By L. T. SACHTLEBEN and G. L. ALLEE

The general properties of a reflective optical system of the Schmidt type are discussed, with particular reference to practical considerations of design and application in the theater. The relationships of focal length, projection distance and incident screen illumination are illustrated. Also discussed are the factors on which resolving power and fine-detail contrast depend. Some facts relating to the design, material and application of the aspheric or ogee lens are given.

THE PROBLEM of satisfactorily projecting a kinescope image upon an external screen has concerned television engineers for many years. Early attempts were made with ordinary projection or photographic lenses of both domestic and European origin. The difficulties were many and serious, and were never completely overcome. One of these was that the face of the kinescope had to be flat or even concave toward the lens, because of the shape of the image surface of the lens. Such shapes are not good from the standpoint of the electron optics of the kinescope, and they are not good mechanically, especially if the tube is large. Added to this was the practical impossibility of getting a lens that would pick up enough light from the kinescope to produce a magnified screen image of adequate brightness and size for theater use. The kinescope image is low in candlepower per unit area compared with the tungsten and arc lamps used in the usual motion picture projectors. As a result, the light from it has to be gathered much more efficiently than in usual projectors. In other words, the projection optics must have much more speed for theater television projection than for motion picture projection from film.

The answer to the need for an ultra-speed system began to take form in the middle 1930's. Donald O. Landis, an optician and designer and maker of telescopes, got the idea that the new high-speed Schmidt astronomical telescope could be used for projection television. This instrument covered a wide field at efficiencies ranging five to ten times greater than the best available lenses. Also, it *required* the face of the kinescope to have the convex shape

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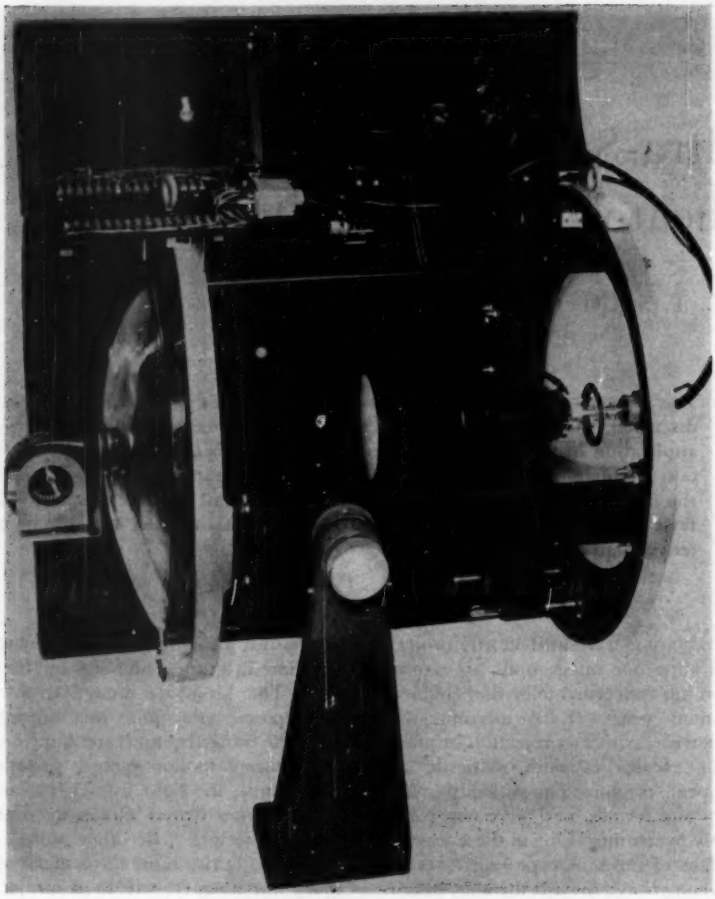

Fig. 1. RCAPT-100 Ultra-Speed Projection System.

which is normal in kinescope design. Landis, working in the RCA television laboratory, built the first model ever made that proved that the optics of the Schmidt telescope could be modified to project sharp and brightly illuminated television images. Working with E. G. Ramberg and I. G. Maloff, he also constructed the first ultra-speed optical system of this type for theater television projection,[1] and the first patent on the adaptation of the Schmidt optics to television use was issued to him.[2] Many of the practical problems of optical design and economical construction were later worked out by D. W. Epstein and I. G. Maloff who also applied the Schmidt optics to home receivers.[3–5]

The theory of reflective optical systems of this type has been extensively discussed elsewhere.[6,7] This paper will be restricted to practical aspects of the system

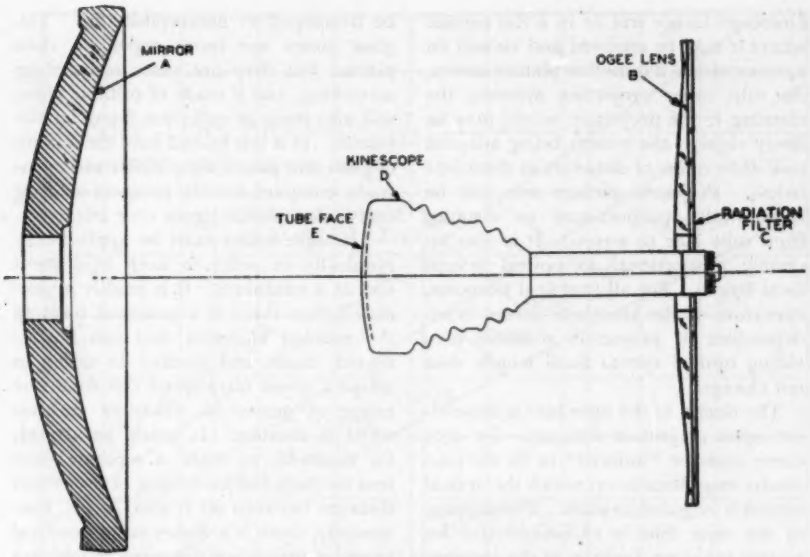

Fig. 2. Schematic of RCA Ultra-Speed Projection System.

which may be of interest to applications engineers and exhibitors.

Nature and Performance of the Ultra-Speed System

The RCA Ultra-Speed Theater Television Optics (Fig. 1) are currently being built in a focal length of 15.515 in. and an effective optical speed of $f/0.82$.* This is a suitable focal length for a large number of theater installations where pictures up to 15 × 20 ft are to be projected from a 7-in., 80-kv kinescope. The system is capable of delivering a 2-ft-c highlight level to the screen under these conditions, from kinescopes of present design.

The optical system has two basic optical parts: a concave spherical mirror; and a low-power ogee lens at its center of curvature. In its meridian section the curved surface of the lens is seen to have a generating curve in the form of an S or ogee, hence the name. These parts are shown, respectively, at A and B of Fig. 2. The focal length of the ogee lens is of the order of 20 times that of the entire optical system. If the ogee lens is not made of a suitable flint glass, a radiation filter must be mounted approximately in contact with it as shown at C of the figure. Such a filter becomes, of necessity, a part of the optical system and its surfaces must be made sufficiently flat and parallel to have the minimum possible effect upon the image. The kinescope tube is located at D on the axis of symmetry of the optical system, with its face, E, directed toward the mirror. When the radius of curvature of the kinescope face or screen is equal to the focal length of the optical system (of the order of one-half the radius of curvature of the spherical mirror), the

* A System that gathers a cone of light 90° in diameter has a speed of $f/0.71$. In a theater television projection system, the mirror must be masked out at the center to prevent reflection of light directly back to the face of the kinescope. Taking this into account, the Ultra-Speed System has a net optical speed of $f/0.82$.

kinescope image will lie in a flat surface where it may be received and viewed on a conventional flat motion picture screen. As with other projection systems, the distance to the projection screen may be freely chosen, the system being adapted to a wide range of distances as described below. Projected picture size will be substantially proportional to distance from tube face to screen. It is also inversely proportional to optical system focal length. For all practical purposes, curvature of the kinescope screen is independent of projection distance providing optical system focal length does not change.

The design of the ogee lens is dependent upon projection distance. Its ogee curve must be "tailored" to fit the particular magnification at which the optical system is intended to work. The purpose of the ogee lens is to compensate for certain inherent qualities in the imagery of the outlying portions of the spherical mirror, and the needed compensation changes with projection distance. The lenses supplied with the systems are carefully designed to suit the distance from projector to screen. The focal length of the optical system remains unchanged when lenses are changed to take care of a series of projection distances.

In manufacture, the ogee lens is given its shape by a master surface. The exact methods used depend upon the material chosen for the lens. Sagging or "dropping" methods are used with glass, casting with thermosetting materials, and pressing with thermoplastic materials. Whatever the material, preparation of the master surface and the process of forming the lens are carried out with great care. The lenses are made by the best techniques that it has been possible to develop.

At the present time the Ultra-Speed System uses only glass lenses, since they are the best obtainable. There is every reason to expect lenses to be made just as well from plastic materials, and it is anticipated that suitable techniques will be developed to accomplish this. The glass lenses are more expensive than plastic, but they are more resistant to scratching, and if made of suitable glass, will also serve as radiation filters for the system. It is not known how the quality of glass and plastic ogee lenses will eventually compare, but the prospect of lower cost makes plastic lenses very attractive.

The ogee lenses must be applied economically in order to keep equipment cost at a minimum. It is readily appreciated that there is a practical limit to the number of lenses that can be designed, made and stocked in order to adapt a given ultra-speed system to the range of projection distances encountered in theaters. It would be absurd, for example, to make a separate ogee lens for each 1-ft increment of projection distance between 40 ft and 70 ft. Fortunately, there is a rather large practical range of projection distances at which a given ogee lens may be used by merely focusing the system accordingly. This range is observed to extend from about 10% more than ideal design distance to about 15% less. Additional flexibility results from changing kinescope raster dimensions electrically. An extensive range of picture sizes, as well as projection distances, is therefore available with a projection system equipped with a single ogee lens. Two different lenses will adapt the projection system to a large range of projection conditions as illustrated in Fig. 3.

The amount of light received by the optical system from each unit of area on the kinescope screen depends on the angular diameter of the cone which the optical system effectively subtends at the faceplate. In the Ultra-Speed System this angle is approximately 90° for maximum efficiency consistent with best image quality. It is obvious that if this light is projected into a small picture a brighter screen will result than if it is projected into a large picture, because the total light available is approximately constant. At long throws, a given optical

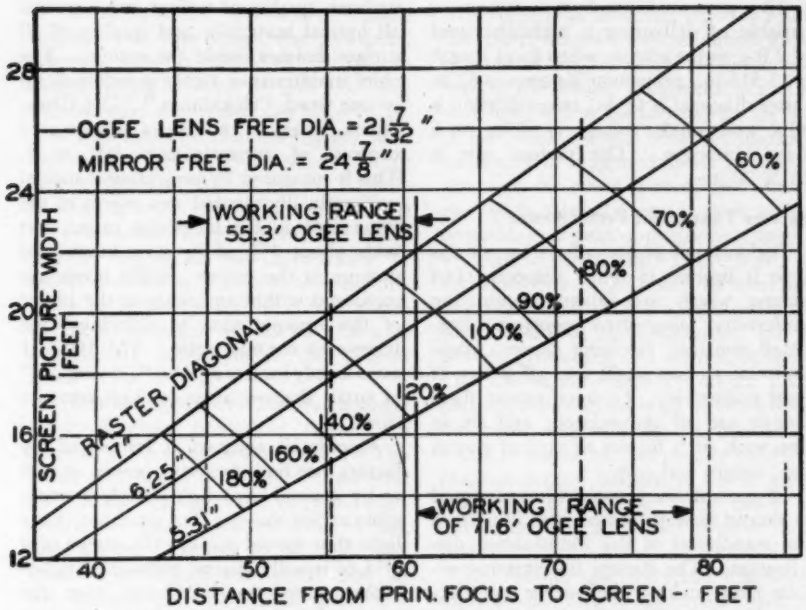

Fig. 3. This illustrates range of projection distances available with the 15.515-in. focal length Ultra-Speed System by use of ogee lenses designed for ideal projection distances of 55.3 ft and 71.6 ft. It also illustrates range of picture sizes available by varying kinescope raster diagonal between 5.31 in. and 7.0 in. Curves of constant illumination indicate available range of screen illumination levels, based on a level of 100% at 62 ft from a 6.25-in. diagonal raster. This level is about 2 ft-c in the highlights with currently available kinescopes.

system will produce pictures at lower illumination levels because the pictures are larger. This can be controlled to a limited extent by electrically varying the raster dimensions in inverse relation to the throw. An increase in throw will then be attended by a decrease in raster area. But, since the beam power is not reduced, the raster brightness increases. By this means, pictures can be kept at approximately constant size and brightness over a considerable range of projection distances. For example, it is seen from Fig. 3 that the projection distance can be varied between 57 ft and 67.6 ft with no change in picture size and with an illumination variation of only 10% from the average. Also, picture widths can be varied between 17.2 ft and 22 ft with no change in projection distance and only a 10% illumination variation from the average. When the ogee lens is changed, and a new range of projection distances is entered, the choice of picture brightnesses and sizes available with the particular lens is, of course, altered. In order to have the above-described ranges of projection distance and picture size available with a single ogee lens, the lens would have to be designed for an ideal working distance of about 63 ft. The ogee lenses used with this system are presently being made for an ideal projection distance of 62 ft. Future installation requirements will determine the choice of additional lenses.

The present Ultra-Speed System is capable of delivering a highlight level of 2 ft-c to the screen, when focal length is 15.515 in., projection distance is 62 ft, raster diagonal is $6\frac{1}{4}$ in., magnification is 48× and anode voltage is 80 kv on a 7-in. kinescope. The picture size is 15 × 20 ft.

Factors That Limit Performance

Performance of optical systems of this type is limited in many respects, chief among which are image illumination uniformity, large-area contrast, fine-detail contrast, resolving power, maximum projection angle and efficiency of light utilization. To some extent these factors are all interrelated, and tie in also with such factors as optical system size, weight and cost.

In general, the projected images equal or exceed those projected from film, from the standpoint of flat illumination distribution. The flattest illumination results from making the mirror considerably larger in diameter than the minimum required to fill the ogee lens with light from the center of the raster. This rapidly increases size, weight and cost of the mirror, however, and it has been found practical to limit the mirror diameter to about 10% in excess of this minimum. Illumination at the sides of the picture exceeds 80% of the center at a magnification of 48×.

Large-area contrast depends upon design factors, quality factors and maintenance factors, because all of these influence the amount of stray light (light not directed to formation of the desired image) that emerges from the system to generally dilute contrast. Stray light also includes light returned to the kinescope screen by the system or by the projection screen. Design factors include surface coating of ogee lens (and radiation filter, if used), central blocking of the mirror, presence or absence of a radiation filter, finish of mechanical parts, etc. Quality factors include workmanship on all reflecting and refracting surfaces, quality of surface coatings and all optical materials, and quality of all surface finishes inside the system. The chief maintenance factor is summed up in one word, "cleanliness." The Ultra-Speed System is capable of a large-area contrast of approximetely 100 to 1. This is measured by projecting a special uniformly illuminated test object of the same area as the kinescope raster, but with about 1% of its area black and opaque at the center. Light levels are measured within and without the image of this opaque area to determine the large-area contrast ratio. The 100-to-1 ratio amply insures against "graying out" of small shadow areas in high-key pictures.

Fine-detail contrast is influenced by factors that limit resolving power, as well as by general stray light which is negligible as just shown. For example, if the light that should go into the image of a grid of equally spaced parallel lines becomes uniformly distributed over the image of the grid, the contrast becomes unity and the lines are not resolved at all. Any optical loss of fine-detail contrast is primarily due to imperfections in the imagery of the optical system. This may be due to manufacturing imperfections in the optical parts, or their misadjustment, and may also be due to lack of refinement in the optical design. All these factors may contribute at the same time.

It has proved practical and economical to finish the spherical mirrors so that their effect on fine-detail contrast is entirely negligible. The manufacturing imperfections most responsible for limiting fine-detail contrast are to be found in the ogee lens. These imperfections consist mainly of very small ripples or "zones" in the ogee surface of revolution, and also in failure of the surface to be purely one of revolution. The greatest care is taken in manufacturing to keep such errors at a minimum and methods are now being improved as rapidly as possible.

In the present ultra-speed optical systems with flint lenses, the fine-detail contrast ratio at 600 lines per picture height ranges between 2.0 and 3.0. The present goal is to raise this ratio to 10. The contrast ratio changes rapidly with line number and at 200 lines per picture height it ranges from 30 to 60. While contrast ratios of 2.0 and 3.0 at 600 lines do not satisfy development and commercial engineers, the appearance of 600-line detail at a normal viewing distance of $1\frac{1}{2}$ screen widths is well above the point where it would be a serious commercial limitation at the present time.

When the ogee lens is made of a single peice of glass, fine-detail contrast is limited by chromatic aberration. The effect of this can be reduced somewhat by making the ogee lens of low-dispersion crown glass instead of flint. A flint filter screen then has to be used, and unless it is finished with great care, its two surfaces can more than offset any improvement to be realized from the crown glass. Chromatic aberration effects can be further offset by a change of magnification. The use of a larger kinescope with shorter projection distance will make the chromatic effects smaller in relation to the size of the picture. It is estimated that the use of crown glass in place of flint, and of a 10-in. kinescope in place of the 7-in., can relatively reduce the area of the chromatic confusion disk a maximum of 80%. Another approach is to make the ogee lens of two different glasses and development work is proceeding along this line. This may involve manufacturing complications, and result in a more expensive lens. It is too early to predict the practical outcome of these approaches to the problem.

Any increase in kinescope size involves an increase in projection angle. This is attended with some increase in vignetting, and also with a tendency toward reducing detail contrast and resolution at the corners and edges of the picture. The vignetting, however, tends to retard the loss in contrast and resolution at the expense of brightness in the outer portions of the image. In general, it can be said that, unless an increase in the size of the kinescope will yield an improvement such as suggested above in connection with the effect of chromatic aberration on fine-detail contrast, there is little or nothing to gain optically by choosing wide-angle projection. If the power in the kinescope beam could be increased in direct ratio to the raster area, the story would be quite different, but in present kinescopes this cannot be done. The conversion efficiency of the phosphor increases a moderate amount when the raster area is increased, but an increase in kinescope size usually results in reduced screen brightness for a given projected picture size when using an ultra-speed optical system of given focal length.

The factors that influence fine-detail contrast also largely determine limiting resolving power. When flint lenses are used, the limiting resolution of the ultra-speed system is 1200 television lines per picture height, or better, in all parts of the picture. It exceeds 1800 lines in the center, and the television scanning lines are clearly reproduced throughout the picture. The present goal is a limiting resolution of 3600 lines.

Proper location of parts is essential to good resolution and detail contrast in the image. All parts of the assembly are carefully made to insure accurate locations, and adequate adjustments are provided for locating the kinescope with reference to the optical parts. The center of curvature of the faceplate must be on the axis of the optical system, and installation and maintenance engineers are provided with means of testing to insure that the adjustment is properly made. Special installation and maintenance tests are also made to insure that the axis of the ogee lens is adjusted to pass through the center of curvature of the mirror.

It is obvious that an optical system of this type can be increased in efficiency up to the point where it gathers all the light that the kinescope is capable of radiating into a hemisphere. However, image quality falls off, and weight, size and cost increase as more light is gathered. All things considered, efficiency is at a practical maximum when the system gathers only the light within a cone of approximately 90° diameter, which is about one-half the light radiated. Other losses due to tube-blocking, obstruction of light by mechanical parts, absorption by the mirror, and reflection losses at lens surfaces bring the efficiency of light utilization down to about 30%, depending upon kinescope diameter. This is still about five times the efficiency of an $f/2$ projection lens.

When the ogee curve of the lens is modified to take care of projection distance changes in excess of a nominal 10% to 15%, the diameter of the lens must change also. The change is greatest in the range of low magnifications. From 5× to 10×, the ogee lens diameter increases about 20%. From 10× to 20×, the increase is about 9%. Between 20× and 40×, it increases only about 5%. The ultra-speed system requires lenses of the largest size because it operates at high magnification in the theater.

The ogee lenses supplied with these systems have been very carefully computed to make the system completely free of spherical aberration at the center of the picture, where it is most desired to have maximum detail and contrast. Also, care is taken to balance the chromatic aberration inherent in the lens in such a way as to minimize its effect on contrast and avoid the appearance of color in the picture. The effects of the thickness and curvature of the faceplate of the kinescope are taken into account in the computations. The design of each lens is carried through with the greatest possible care and many computational checks are made on the completed design to insure against errors that would spoil the shape of the lens. Manufacture of the lens is based upon coordinates computed at radial intervals of 1 mm, or for about three hundred zones in the case of the 15.515-in. focal length system. Care of this order is carried right on through the processes of lens manufacture. The good performance of the ultra-speed system depends upon the greatest care being taken in design and production of the ogee lens.

The high limiting resolution of 1200 lines or better over the entire picture is an indication of the extreme flatness of the image produced by this system. This is especially emphasized by the fact that the depth of focus of a system of this speed and range of magnifications is very small at the screen. A movement of the screen of 3 or 4 in. will cause marked defocusing of the image and loss of detail contrast and resolution. As a result of this limited focal depth, not only must the curvature of the image be very small, but the system must be carefully installed to insure that the axis of projection is at right angles to the screen. Very little tilt of the screen away from its optimum position is permissible.

In closing, the writers would like to acknowledge the efforts of all who have in any way contributed to the successful performance of this optical system, especially those of D. W. Epstein, I. G. Maloff, D. J. Parker, G. L. Dimmick, J. E. Volkmann and R. V. Little, Jr., of the Radio Corporation of America, and personnel of the American Optical Company at Southbridge, Mass.

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Discussion

Dr. F. N. Gillette: What is meant by the term "ogee"?

John E. Volkmann (who presented the paper): According to the dictionary, the name "ogee" is applied to an object having an S-shaped profile. Because a radial section of the lens clearly has such a profile, the name is obviously applicable. This type of lens has been variously called a "corrector plate," a "corrector lens" and an "aspheric lens." It is felt that the name "ogee" lens is more descriptive of the form of the lens than any of the older terms, and has the advantages of shortness and phonetic simplicity.

Dr. Gillette: A further point, I think I heard an implication that by changing the design of the ogee lens you could change the focal length in some appreciable quantity. Is that correct?

Mr. Volkmann: The focal length of the optical system remains unchanged when the ogee lenses are changed to take care of a series of projection distances, unless a change is made in the radius of curvature of the concave mirror.

Dr. Gillette: It just has been my impression that the ogee lens contributed very slightly to the net focal length of the whole system, and consequently I would be very much interested in learning your method whereby changing that lens would change the total focal length appreciably.

Mr. Volkmann: The ogee lens plays only a small part in determining the net focal length of the whole optical system, as you suggest. The curvature of the concave mirror largely determines the net focal length of the system.

Mr. Strickland: Is the barrel sufficient shield for radiation to prevent physical harm?

Mr. Volkmann: I presume you are referring primarily to the x-ray radiation effects?

Mr. Strickland: Yes.

Mr. Volkmann: The barrel is completely shielded, not only with respect to the metal parts themselves, which are fully lined with the proper thickness of lead, but, as explained, the radiation filter is a glass that cuts down the x-ray radiation so that the unit is completely protected and meets all the Underwriters' requirements with regard to x-ray shielding.

A. D. Fowler: You mentioned that the optical system presently controls the fine-detail contrast. I'd like to know about the spot size on the projection tube itself. Is it any worse or better than a kinescope receiver? Do you know that? Is it so much better that it's only the optical parts that control the fine detail?

Mr. Volkmann: Limiting resolution of the 7-in. projection kinescope spot is approximately 700 TV lines. There is usually no trouble resolving the monoscope test pattern. This pattern has a resolution wedge that extends to 500 lines. The projected fine detail contrast is the resultant of contrast in the kinescope and in the optical system. The figures given in this paper refer to the optical system only. The contrast would not be as good if the effects of the kinescope were included.

Independent Frame—An Attempt at Rationalization of Motion Picture Production

By LT.-COL. G. R. STEVENS, O.B.E.

To reduce the cost and improve the efficiency of motion picture production, the Independent Frame technique, sponsored by the J. Arthur Rank Organization of Great Britain, aims at a flow system of production. This method, which has had marked success in a series of experimental films, now is being developed for use with television cameras and for remote direction and editing.

THE PROBLEM OF COSTS always has haunted the motion picture industry. The production of a picture abounds in loose ends and although many attempts have been made to improve on this state of affairs almost all of them have failed. A popular concept of economy has been to take the script, hack some scenes out of it and so save shooting time. Needless to say, this process in itself results in additional confusion.

For a number of years it has been apparent to some people within the industry that more thought should be given a particular production before it reaches the studio floor. The studio floor is an expensive place to think, because it costs a lot of money to have a cast and crew stand by while lighting, camera angles, last-minute costume changes and even the placement of properties are decided on.

In other lines of business it has been possible to circumvent such misadventures. Modern industrial technique is based on the theory that nothing ever need be out of place and that it is possible to eliminate human errors as cost factors through the establishment of assembly-line production methods. The lack of long-term preplanning and the absence of the orderly procedure of the assembly line is what has made the production of motion pictures such a wasteful and costly process.

Such thoughts as these revolved in the mind of a young Englishman named David Rawnsley, a set designer in one of the British studios. In the course of designing and building the sets for more than 200 films, he had ample opportunity to observe the costliness and waste of motion picture production routines. He wondered if the crowded stages, the interminable delays, the chopping and the changing, the noise and the con-

Presented on April 30, 1951, at the Society's Convention at New York, by Lt.-Col. G. R. Stevens, O.B.E., 144 Strathern Ave., Montreal West, Canada, upon behalf of Television Film Productions Ltd., London, England.

fusion, and the other uneconomic aspects of motion picture production were really necessary. By 1944 he thought he saw a way out, a method by which modern industrial assembly-line technique could be applied to film production.

He put his ideas before J. Arthur Rank and was invited to become Head of the Research Department of that organization. He was given generous facilities for experiment and in the next four years spent roughly the equivalent of $3,000,000. By the end of that period, the broad outlines of a new method of motion picture production had emerged; whereupon, Rawnsley formed Television Film Productions Ltd. to act as consultants on the processes which he had devised. The Pinewood Studio was re-equipped for experiment, and the J. Arthur Rank Organization authorized a series of films to be produced by Rawnsley's methods.

There was nothing experimental about these first productions under the new technique. They were full-budget pictures with costs based on normal production methods. The earliest picture to be placed in work was given a budget of $600,000 and those which followed were in the same cost bracket.

The J. Arthur Rank instructions to Rawnsley were rigorous. His processes had to justify themselves not by slight, but by marked economies. The completed films had to be not only equal to, but better than, standard productions, both in technical and artistic values. Above all else, the new processes had to justify themselves by simplifying the routines of production; by proving that it is possible to make motion pictures of high quality with less trouble, with less waste of time and with less expenditure.

Independent Frame and Live Action

Rawnsley called his process Independent Frame. He regarded everything but the actors as the frame of the film picture. The sets, the properties and perhaps most important of all, the perspectives, were to be built as a unit, transported as a unit, set as a unit and struck as a unit. His settings, his properties and his vistas would be put in place, would be used, and afterward would be removed in from one-tenth to one-third the time expended in ordinary stage preparations. In addition, a good many of the stage settings would be dispensed with entirely through the extended use of back projection as well as other special effects and lighting processes.

Thus, in Rawnsley's plans, there would be two partners in production — the Independent-Frame partner and the Live-Action partner. Neither would interfere with the other. Instead, they would keep out of each other's way and so save time and money.

The first necessity was a certain amount of reconstruction in Pinewood Studio. Twin stages were built, each 200 by 175 ft in area, with a collapsible insulated partition between them. The studio area beyond the stage was arranged on the assembly-line principle. Figure 1 shows that it begins at the area marked Materials. Thence, all stores proceed to the area marked Shops, which includes carpenter, plaster, paint and other construction shops. Adjoining the shops is the Assembly Bay, with the Scene Dock on one side and the Waiting Bay on the other. The Scene Dock is not shown on the chart; it may be situated either on one side of the Assembly Bay or in its rear. In the Assembly Bay, the sets are mounted on set floats, or mobile rostrums, as they are called in England. If a set is too large for one float, the rostrums may be interlocked. Minor finishing jobs are done in the Assembly Bay; thereafter, the Property Department takes over and dresses the set.

The set floats then are towed into the Waiting Bay which is divided from the stage by acoustically insulated sliding doors. The Waiting Bay must be large

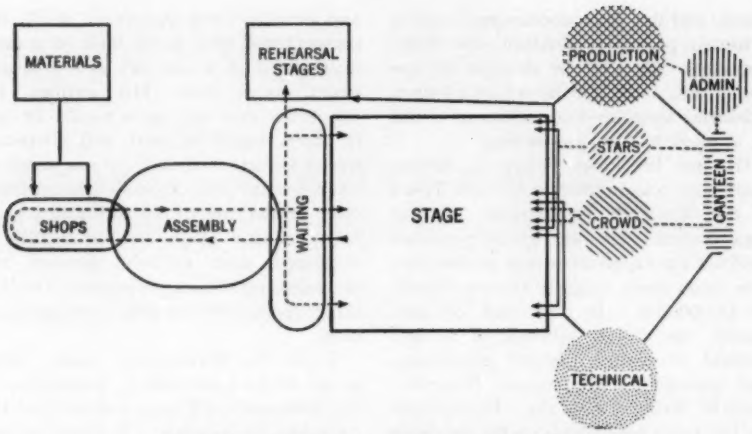

Fig. 1. The Independent-Frame assembly line.

enough to accommodate the live sets going on stage and the dead sets coming off.

In order to dress the stage with minimum confusion, the majority of sets are flown into position by the aid of an overhead gantry. This gantry consists of five banks of running bridges, each a 24-ft section, each section operating independently and capable of carrying a point load of three tons. The special rehearsal stage is off on one side, out of the way. On the front of the Stage, individual approaches have been marked out for Stars, for bit players and supernumeraries, and for technicians and production staff, in order that each element in the production group will interfere as little as possible with each other. The dressing rooms and administrative offices are behind the area marked Canteen.

The involved and radical lighting setup employed in Independent Frame has been described elsewhere.[1] Suffice it to say, nearly all Independent-Frame lighting is indirect. An ingenious reflector system is employed which dispenses with light rails and reduces the candlepower of the normally lighted set by almost two-thirds.

Construction of Independent Frame

The construction of Independent Frame begins, as all modern industrial technique begins, with intensive planning. It is not suggested that under the normal system of motion picture production planning is not intensive. In its primary stages, Independent Frame embodies little that is new. It simply carries existing practices further than is customary in the normal production.

From six to nine months before shooting date the Independent-Frame team goes to work. It begins by blueprinting the production. After the blueprints, the next step is the prefabrication of all backgrounds.

All settings must be organized and complete to the last detail before shooting begins. The first step is a library job, carried out by one or more still photographers who go on location with precise instructions as to what is needed for background process work, for transparencies, for superimpositions and for all other setting requirements. Moving and static matte effects, foreground transparencies, miniatures and models, special photographic effects and other

Fig. 2. *A Warning to Wantons* shot, with the vista in back projection. The colonnade vista, in which the girls and the nun are standing, shows in brilliant detail to great depth.

accessories are produced and fitted into the general background scheme.

Live action may be incorporated in this synthetic background through the inclusion of film; beyond a window or a door, crowd scenes, rolling waves or other movements may be introduced. The sum of these various agencies, when coordinated beforehand, is an attempt to bring the location into the studio with the greatest possible realism and at the lowest possible cost.

In his first Independent-Frame sets, Rawnsley aimed at a minimum of construction and a maximum of special effects. His success is evident when his films are examined frame by frame. It is next to impossible to discern where authentic construction ends and where process takes over. Often there is nothing on the set except a chair or a piece of furniture; or, if an entrance is required, there may be a door in its frame. The process background film supplies the remainder of the room.

Warning to Wantons, the first of his feature films, is well worth study, as he tried his complete bag of tricks in it. It is noteworthy for the manner in which the junctions of actual settings and back projection have been disguised, for the way in which transparencies, matte processes and live action have been coordinated in the backgrounds and for the clever use — and equally clever avoidance — of shadows (Fig. 2). In a number of instances Rawnsley succeeded in having an actor reach behind a nonexistent angle for a box of cigarettes. He has had an actor climb three real steps of a staircase, and thereafter left him with his foot in the air, stepping off into the back projection. In a later picture, *Floodtide*, he saved a

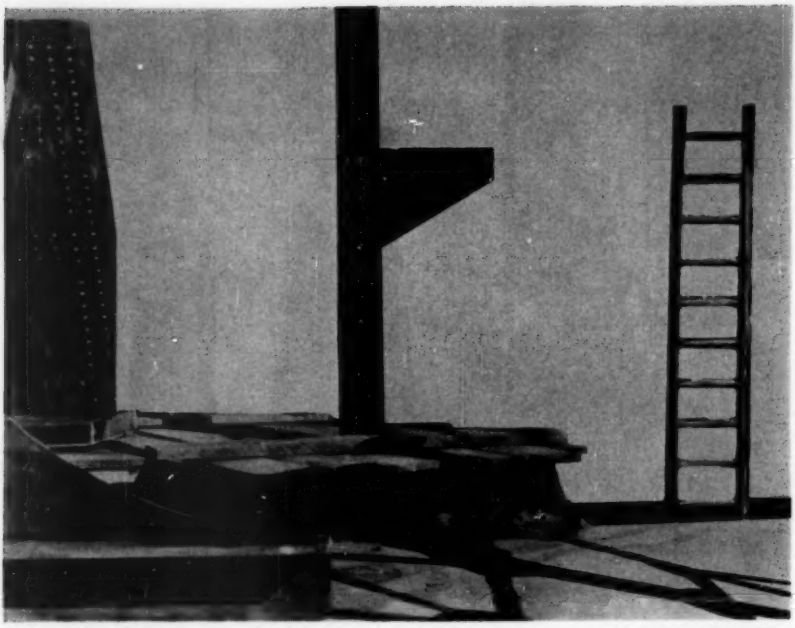

Fig. 3. The actual construction in a ship's cradle, as used in *Floodtide*.

day on location through the use of a real girder in the left foreground (Fig. 3). The remainder of the set was a back projection of a shipbuilding cradle, with superimposition of film to bring the characters across it. A quick cut, and the players stepped out from behind the girder to take up their roles.

When these prefabricated backgrounds of Independent Frame have been completed, they are recorded on a Story Reel for study, for adjustments and for a final O.K. In the same manner, sound effects and music tracks are assembled and recorded. Properties and set pieces follow into the set. Models and foreground miniatures are incorporated. The ideal — and it is quite possible of realization — is to have every stage detail settled and every set organized for rapid mounting and striking before the first rehearsal call. When the shooting begins, the stage crews, except for a minimum of technicians, have completed their tasks. The sets are final, the lighting is correct, the properties are in place and the camera angles have been decided on. The Independent-Frame production then is ready to roll. No time has been wasted nor have any costs been incurred on the shooting stage.

The Story Reel

So much for the Frame of the picture. In similar fashion the story treatment has been organized beforehand. About the same time that the Frame Team gets down to business, from six to nine months before shooting date, the Scripting Team starts to work. This team consists of the producer, the director, the writer, the set designer, the editor, the sound director and the cameraman. Their objective is to present their individual problems to each other in

order to agree on a joint conception of the production.

In British studios, under ordinary production conditions, an average of two hours in each working day is lost in floor discussions, in reconciling differences of opinion among the technicians, and in chopping and changing the script or its presentation. This does not occur under Independent Frame. When agreement has been reached, a Pre-production Story Reel is filmed. This Story Reel presents orally and visually a timed continuity of the proposed production. Sketches are prepared for every scene; complicated scenes may require several sketches. The sound track of the Story Reel consists of a narrator, who may add whatever musical score or pertinent dialogue he deems necessary to explain the plot or to make the characterizations effective. Thus, at any time before shooting begins, the entire production can be examined in sequence, can be mulled over, or can be altered without costing a minute of floor time. When it finally is approved, the Story Reel forms the basis for the compilation of the actual Shooting Script, which is prepared in the usual manner, with setting, lighting, sound, camera and action directions on one page, and the story and dialogue on the facing page.

Shooting

Now comes the call for the actors. First rehearsals are carried out by principals only. They take from three to four weeks. Thereafter there follow no more than three to five days of dress rehearsals on the process stage. At this juncture the twin stages earn their keep. A previous film may be finishing up on one half of the stage, while the dress rehearsals are conducted on the other half. This is possible only because of the prefabrication both of the Frame and of the Story of the picture, independently of each other. The majority of the technicians have done their jobs and are out of the way. Everything now is ready for the marriage of the Live Action to the prepared Frame and to the other prerecorded film material.

Thus, the shooting of the picture begins and continues under the best possible auspices, without interruptions and without changes. There are relatively few people underfoot and nothing to distract from the task in hand. As a result, the floor time, which is the biggest element in production costs, is cut substantially. More pictures can be made in a year with the existing studio facilities.

The foregoing details of the production organization of Independent Frame are, of course, little more than a summary. First in the field of results comes the all-important factor of economies.

Economies

On the first four pictures produced by Independent-Frame methods, marked savings were effected. As an illustration, the first film, *Warning to Wantons*, was allotted a budget of $600,000. Its actual cost was $360,000. The shooting time had been estimated at 14 weeks. The actual shooting time was 8 weeks.

In each of the six phases of production — the prefabrication of the Frame, the prefabrication of the Story, the Scripting of the Treatment, the Rehearsal, the shooting and the Postproduction Editing — there were noteworthy savings both in time and in money.

Such savings, in the case of a single film, are but a fraction of the economies effected if the studio can be maintained in continuous production. Then it becomes possible to stagger each of the six phases of production, so that key staffs can be employed continuously, moving on from one film to the next while the requisite producers, directors and artists succeed each other on the studio floor at short intervals. Under such conditions it becomes possible, through the many advantages of Independent Frame, to complete as many as twenty full-length features per year on a single twin-stage unit. During the shooting period, a

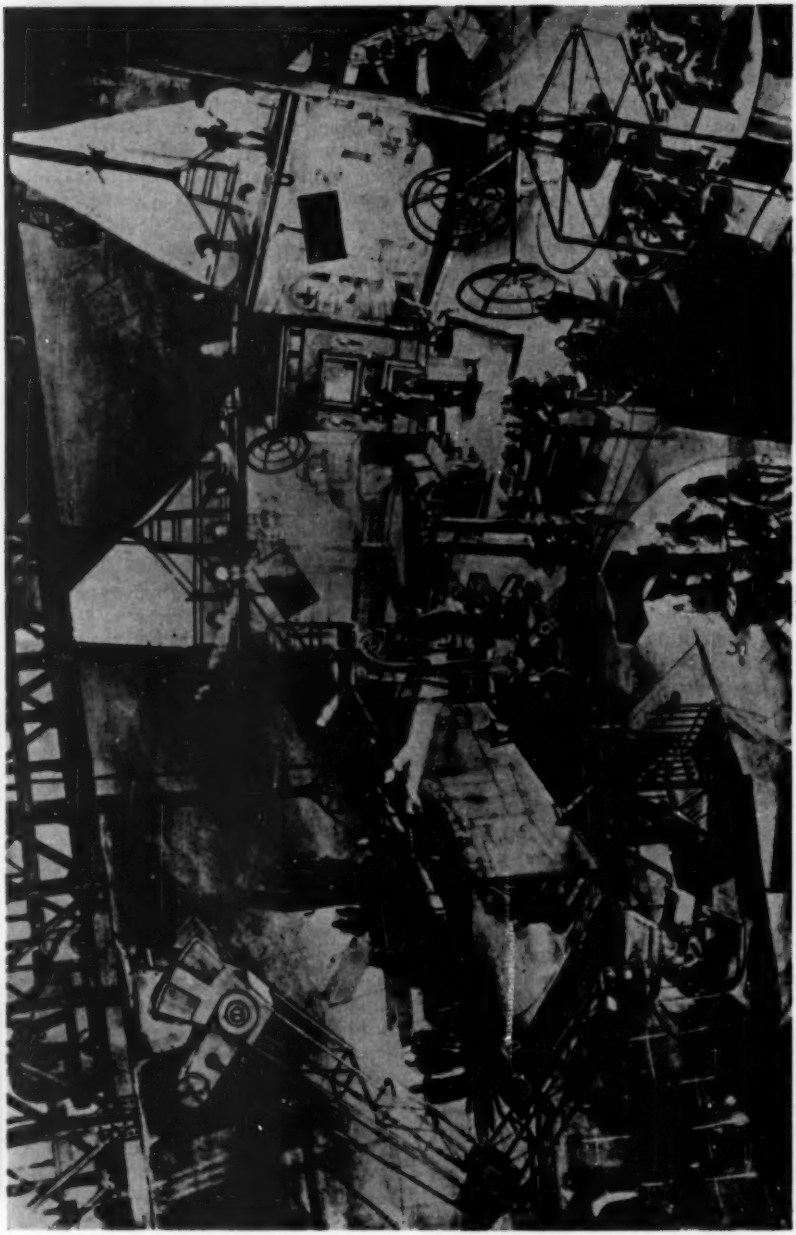

Fig. 4. The electronic stage, on which television cameras replace ordinary film cameras.

yield of ten minutes of finished picture daily is not unusual. Mr. Rawnsley, in his detailed report on the test productions, summarized the achievements of his processes in a single phrase, "Half the time at half the cost, on half the usual stage space."

In addition to immediate savings, there is a long-term economy involved in Independent Frame. Much of the prefabricated Frame is recoverable as library material. It can be combined to form new settings. It can be used for different-language versions of the same picture. The international implications of possessing settings which will allow directors in other countries to employ their own casts and to interpret scenes to suit their own audiences, may prove in time to be an important aspect of the Rawnsley technique.

The first pictures produced by Independent Frame undoubtedly fulfilled the conditions set by the J. Arthur Rank Organization. They saved money with no loss in artistic or technical values. They simplified production techniques.

Reactions

The opinions of technicians on the processes varied widely. There would have been something wrong had it been otherwise. Some denounced the processes as unreal and overmechanical. Cameramen as a whole did not like the process. They felt that their preproduction planning, in which they worked out setups and camera angles in advance, did not do them justice. In addition, they took a rather dark view of so much back projection and superimposition. But there was no evidence in the finished pictures that the camera work had suffered. The actors and actresses, who might have objected to playing against phony backgrounds, were not adversely affected and turned in their customary performances. Directional and administrative staffs were highly in favor of Independent Frame, as it halved their work and their worries. The theater audiences did not detect any differences in the settings and, after all, the customers are the final court of appeal.

Since the first four pictures, there have been several other Independent-Frame productions, most of which have played in New York and in other parts of the United States.

Television in Film Production

The original Independent-Frame technique, however, now is its least interesting aspect. David Rawnsley has moved on to more radical innovations. He always has had in mind the possibility of employing television in film production, since its use would simplify and accelerate his original aim to lower costs without sacrifice of artistic or technical quality. Here again, the Rank Organization backed him up by ordering test productions. As in the first instance, stringent conditions were laid down by which the success of such productions would be judged.

This television technique still is in process of development (Fig. 4). Briefly, six or more television cameras are substituted for standard film cameras on the studio floor. They work on a standard of definition sufficiently high to record the same quality of image as standard film cameras. They are fitted with electronic view-finders which allow the camera operator to examine the picture he is transmitting. These pictures are fed simultaneously onto electronic monitoring screens, not only in the director's control booth but also to other technicians entrusted with cutting, mixing, superimposing and combining the live action on the studio floor with previously recorded material. A combining screen allows the director to prerecord his back projection and matte processes. He thus saves considerable floor time. From a booth which may be built into the wall of the studio or may be slung from the gantry over any part of the stage, the director controls all processes. He studies the results of live action on his preview

screen, he calls for whatever changes he requires, he orders his cuts, his mixes and his superimpositions. Finally, he views the finished product on a main monitoring screen. Only then, when it has received a final O.K., does it pass to the recording room to be placed on film. Immediate processing follows and the film is fed back to the director on a scanner for a last look before he continues with the next scene. Sound is monitored in the same manner as the film images.

It would be foolish to claim that there are no difficulties in this radical process. It is only in its infancy and, like all infants, it squalls occasionally. A well-known British technician-consultant recently published the results of a sequence-by-sequence analysis of three films in order to discover the causes of additional takes and retakes, and the part that television aids and electronic monitoring play in reducing production time. His opinion is that, at the present stage of development, electronic monitoring screens are of less value than rapid "rush" developing, which allows the preceding sequence to be studied on the film within minutes of shooting. The immediate examination of "rushes" is, of course, standard Independent-Frame practice.[2]

The advantages are so great, the possibilities of electronic techniques so vast, that it would be a bold man who would say that David Rawnsley is on the wrong road. It has been stated that others in Hollywood are working toward the same end. It is fair, therefore, to assume that in the course of time Independent Frame will be something very different from what it is at present, but it will be remembered as a pioneer experiment in a new and vastly more efficient technique of motion picture production.

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Progress in Photographic Instrumentation in 1950

By KENNETH SHAFTAN

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THE PURPOSE of this paper is to define the field of photographic instrumentation and to report briefly on the progress that was attained in that field during 1950.

The photographic method is used, according to Dr. C. E. K. Mees,[1] for: (1) the recording of visible images; (2) integrating radiation over long periods; (3) detecting invisible radiation; and (4) measuring the intensity of radiation.

Presented on May 2, 1951, at the Society's Convention at New York, by Kenneth Shaftan, Director, Photographic Instrumentation, J. A. Maurer, Inc., 37–01 31st St., Long Island City 1, N.Y.

Basically, both qualitative and/or quantitative data can be obtained. Relating these basic techniques to the needs of science, it may be seen that the photographic method has found exceptionally widespread use. Indeed, the photographic method is being used extensively in almost every branch of science and engineering. It is significant to note that the photographic industry of the world is three times the size it was in 1939, and that currently two-thirds of all photographic materials produced are used in business, industry, government and science.

I. HISTORICAL

Among the earliest uses of photography were the scientific. In March 1840, nine months after the French government released the daguerreotype process to the world, Dr. John W. Draper took the first successful photograph of a celestial object — the moon. At the Harvard College Observatory, attempts were begun in 1848 to make daguerreotype, or talbotype, pictures of stars,[2] with the first successful results obtained on the star Vega in July 1850. Professor S. F. B. Morse and others were active in this field at about the same time.

The antecedent techniques of motion picture photography developed by Muybridge,[3] Eakins and others were for the study of animal and human locomotion.

Moser, in 1842, first observed radioactive effects on photographic emulsions. The fogging of silver chloride and iodide emulsions by uranium salts was rather thoroughly investigated by Niepce de Saint-Victor in 1867. The researches of Becquerel, the Curies, Wilson and many others used photographic emulsions as instruments in nuclear research. Up to the invention of the Wilson cloud chamber, the emulsions used were those developed for visible spectrum photography. Today we have emulsions especially developed for nuclear studies, and, as a result, there has been a great revival in the use of nuclear photographic techniques. To date, some thirteen nuclear particles have been detected and identified through the use of these techniques.

The early efforts have been refined and extended in application, providing science with many specialties which depend in great measure on the photosensitive medium. Applications have become so widespread and diverse that, compared with the extent of the effort, relatively little has been done to coordinate this field.

II. DEFINITION

To aid in codification and unification of the field encompassing the scientific uses of photography, we need a term to describe it adequately. The term, *photographic instrumentation*, is proposed and defined as: *The use of the photosensitive medium for the detection, recording and/or measurement of scientific and engineering phenomena. Photographic instrumentation* thus includes the apparatus, the techniques, the processes and the applications in scientific endeavors.

III. THE PRIOR STATE OF THE ART

The usefulness of photographic instrumentation has been expanded slowly since its earliest applications but it has received great impetus during the last two great wars. It is not the purpose of this paper to review all that has gone before; indeed, such would be a fabulously complex and difficult task which would take many years, a large staff and considerable funds to accomplish. That this is needed is seen most clearly in the almost daily appearance of new embodiments of old, discarded and essentially worthless devices and techniques.

A number of excellent abstract and digest publications,[4–8] many of them founded over thirty years ago, have attempted to keep us abreast of doings in photographic instrumentation. But this field represents only a small part of the interest of these periodicals. It must be borne in mind that much of the information is in abstract form, requiring the reader to go to the original papers for

complete information and for evaluation of the subject matter. Also, neither the Universal Decimal Classification, nor any other classification method, is considered to have codified this field of knowledge adequately, particularly since the most comprehensive classifications have not been revised in many years.

We, here, entirely or partially exclude a number of specialized spheres of photographic instrumentation which have been given greater impetus than most others: astronomy, spectrography, aerial photography and the orthodox radiography, for example. Work in these fields has had most excellent survey and they have progressed apace as a result.

Concerning the less well established fields of photographic instrumentation, little textual information exists. One of the earliest is on the subject of spark techniques used for the study of "splashes."[9] Another early work was that of Professor Conrady and others[10] concerning a number of photographic applications in science. Photographic techniques are included in Cranz's famous *Lehrbuch der Ballistik*,[11] and in Fink's *Die Photographische Messtechnik*,[12] both of which have not been generally available in this country. Tupholme's *Photography in Engineering*[13] presents a semipopular view of some of the phases of photographic instrumentation.

Early texts on high-speed motion picture photography were written by Magnan in 1932.[14,15] Then, no text appeared on this subject until the extensive papers, first published by Fayolle and Naslin in the *1948 French Mémorial de l'Artilleria Française*, were collected into book form.[16] A short review of photography in astronomy is given in a new Kodak publication.[17]

Light sources of interest to photographic instrumentation are discussed in Bourne's work,[18] while oscilloscopic recording details are covered in a recent Ilford publication.[19] A most interesting book on nuclear applications is that by Powell and Occhialini,[20] and an excellent text by Yagoda exists on the use of nuclear emulsions.[21]

A staggering amount of material exists in the periodical and patent literature from about 1850 to the present. One can readily see that it is beyond the scope of this paper to bring to the reader the state of the photographic instrumentation art prior to 1950. There is a serious gap in the organized record of our knowledge, and it is hoped that a thorough project will one day present all the pertinent information.

Highlights of some of the more important developments of the past ten years in many photographic fields, including some of photographic instrumentation interest, are given in the new publication by American and European scientists edited by D. A. Spencer.[22] This book is necessarily brief and in summary form, but it is a most helpful review which the author hopes will become a continuing and frequent work.

Two new French works are of interest: *Chronophotographie des Champs Aerodynamiques* by Bourot,[23] covering the use of smoke particles for making aerodynamic flow visible, and *Le Cinéma Scientifique Français* by Thevenard and Tassel,[24] which is in the nature of a review of French application of motion picture photography techniques to scientific investigation and to education.

A book recently published in Germany, is noted: *Die Photogrammetrie in ihrer Anwendung auf Nichttopographischen Gebieten* by Lacmann.[25]

The High-Speed Photography Committee of this Society has inaugurated work on a treatise on photographic instrumentation by specialists in each phase of this field. This work will necessarily take some time to produce, but will fulfill a long felt need for complete and competent technical information. The Committee will no doubt present progress information as work in the field proceeds.

IV. PROGRESS IN 1950

A. Introduction

In writing this paper, it became apparent that information was to be found in an increasingly large number of scientific journals, both domestic and foreign. No single abstract or digest publication codifies the published literature in photographic instrumentation. Very often, instrumentation data are omitted from the abstract and can be unearthed only by further scrutiny. Sometimes, knowledge of the field of endeavor, or of the past work of the investigator, will lead one to information on this subject. In many cases, it was a true disappointment to find that only the briefest mention was made of the techniques employed.

In all, some 12,000 abstracts were scanned and some 500 of them were chosen for further study. Some fields have been examined only briefly and others not at all. Thus, this paper cannot be considered to be exhaustive.

An attempt has been made to read as many papers as possible and where they were not readily available, reference was made to the abstract and digest journals. In a survey of this sort, only a brief mention may be made of any one instrument or technique, and the reader is referred to the original paper listed in the bibliography for more complete information.

B. High-Speed Still and Motion Picture Photography

A number of high-speed cameras were introduced during 1950, covering a remarkable range of frame frequencies and indicating a very interesting future potential.

A modification of the gun camera used in aircraft was accomplished to provide for 1000 frame/sec for use in rocket studies.[26]

The Beckman & Whitley Temporal Sequence Camera[27] provides quantitative measurements of the velocity and acceleration of objects moving at high speeds, of the order of 2000 mph. This camera uses a slit technique, recording time sequence in a vertical plane passing through the optical axis of the lens. It is equipped with an electronically regulated power supply and timer control. Time is recorded in the form of numbers showing lapsed seconds and hundredths of a second with intermediate pips spaced at thousandths of a second. Printer dials accumulate 1000 sec/turnover and longer periods may also be handled. Event timing can also be recorded. Continuously variable film speed in either direction permits the recording of events progressing in either direction. The film used is 35-mm in 120-ft magazines. A strip is produced wherein the image is a geometric plane figure of generation with the horizontal coordinate representing time. Events taking place vertically in the slit plane are expanded horizontally, coordinated with the calibrated time scale. Gaseous-discharge light sources may be used in conjunction with this camera to produce conventional sequence photographs. The camera may also be used to record phenomena such as cathode-ray oscilloscope traces, acting as a continuously moving film camera.

A group at the Department of Aeronautical Engineering of the University of Minnesota, in a paper[28] before this Society, discussed the British Marley High-Speed Camera which provides for 58 pictures at rates up to 96,000 frame/sec. This camera had been described previously in British and French journals. It is a relatively simple device operating on the principle of a vernier and has only two moving elements: a slit disk and a capping shutter which consists of a similarly slotted disk, Figs. 1 and 2. The film is approximately 2 m long, 35 mm in size, daylight loaded and held stationary during photographing. In order that the photographs may be studied by projection, it is necessary to rephotograph each of the frames onto motion picture film. The frames produced in the Marley camera follow a complex se-

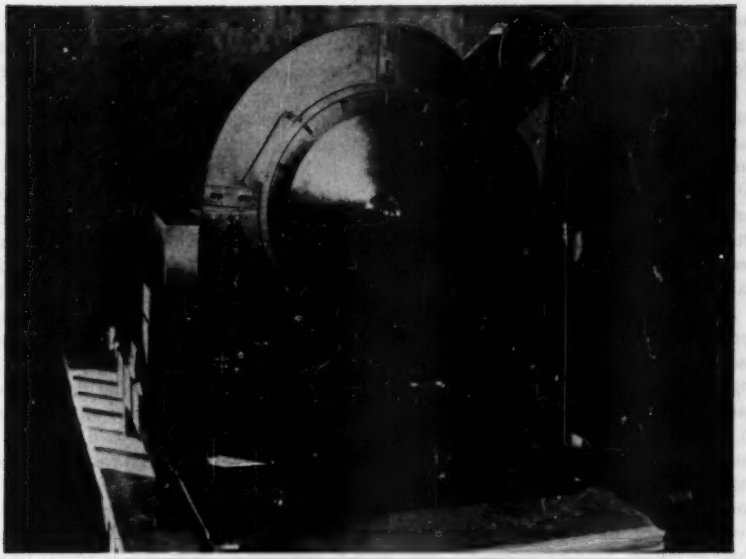


Fig. 1. The Marley Very High-Speed Motion Picture Camera (front view). (Courtesy of Hinz, Main, & Muhl.[28])

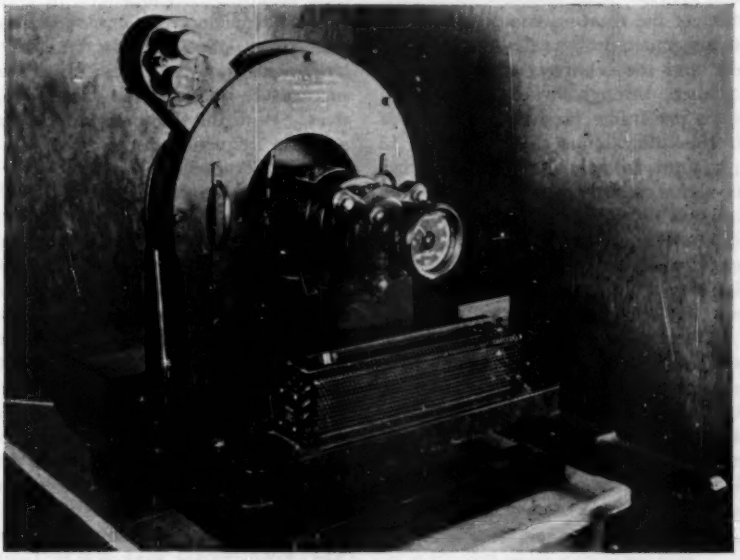


Fig. 2. The Marley Very High-Speed Motion Picture Camera (rear view). (Courtesy of Hinz, Main, & Muhl.[28])

quence, with frame No. 2 produced 48 frames following frame No. 1. Frame No. 3, again being displaced 48 numbers, is in position 38, and so on. The maximum frame frequency, with the rotor disk turning at 6000 rpm, is 96,000; the exposure duration per frame is approximately 10.5 μsec with the overall exposure time for 59 frames at 618 μsec. Gaseous-discharge tubes (FT403 and FT503) were used at various energy levels as illuminants.

A rather ingenious hand-held, high-speed motion picture camera, the Rotax,[29] uses the optical compensation of a rotating prism for image formation. This camera was designed by Askania Werke in Germany before World War II, and an early model, picked up as an aftermath of war, has been tested in this country. The Rotax employs an octahedron prism fixed axially on the same shaft as the focal plane sprocket. As the prism rotates, the image is transmitted to the film by means of a multiple fixed-prism system. The inherent synchronization of the rotating compensator and film movement produced by this arrangement and the relatively small angle of incidence through which the prism rotates per frame produce an image of fair resolution. The camera weighs 13 lb, is approximately 11 × 8½ × 11 in., has a continuously variable speed from 24 to 600 frame/sec, and carries 100 ft of 35-mm film. Lenses of various focal lengths may be used by means of an adapter. The motor speed may be controlled by varying the voltage applied.

Reporting before this Society, Dr. Paul Fye[30] of the Naval Ordnance Laboratory disclosed the design of the Jacobs and Klebba* high-speed motion picture camera. This camera follows essentially the principle of the Bowen and the Miller 50,000 frame/sec cameras. An image of the subject is focused onto a rotating mirror having its axis of rotation on the focal axis of the taking lens. The rotating mirror, having its plane of reflection 45° to its rotational axis, reflects the image successively through 100 framing lenses to stationary film mounted on the inside of a drum. The mirror may be revolved to speeds of 18,000 rpm, producing at this speed 100 frames at a frequency of 30,000 frame/sec. A capping shutter is employed to prevent multiple exposures. This paper also gives a short exposition of the event synchronization techniques and results of Fastax and Eastman high-speed motion picture camera photography using flashbulbs as light sources in the study of underwater explosion phenomena.

Another multiple-lens camera, but one operating on a different principle from the preceding device, has been described by L. Bull[31] of the Institut Marey of Paris. This camera produces 50 circular images of 16-mm diameter on a plate measuring 13 × 18 cm. Bull uses 50 lenses of 25-mm focal length, *f*/3.5, arranged in 7 staggered arcs of concentric circles, forming a close group. A shutter, in the form of a large-diameter disk fitted with slots, successively uncovers the various objectives. With the shutter rotating 60 rps, a frame frequency of 3,000/sec is produced. Because of parallax caused by the distance between the extreme lenses (of the order of 2 ft at an object distance of 3 to 4 m, where it becomes negligible), the camera cannot be used for cinemicrography or for the photography of very close objects. The camera may be used to project the images produced in their normal order by mounting a projection source thereon.

A multiple-slit focal plane scanning shutter, used in conjunction with a rotating mirror, forms the basis of an ultra-high-speed motion picture camera developed by M. Sultanoff[32] of the Ballistics Research Laboratory, Aberdeen, Md., following the work of F. E. Tuttle.[32] The object to be photographed is imaged by a lens of long focal length onto a grid

* S. J. Jacobs, Naval Ordnance Laboratory, and A. A. Klebba, Woods Hole Oceanographic Institution.

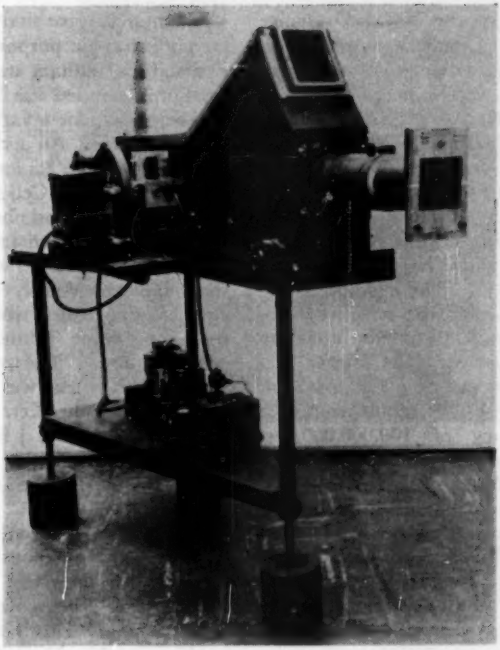


Fig. 3. Sultanoff-Ballistics Research Laboratory Ultra-High-Speed Motion Picture Camera. (Courtesy of M. Sultanoff.[32])

(two types are described, 0.0005- and 0.0001-in. slits cut on opaque coated glass 4 in. × 4 in. × $\frac{1}{8}$ in.). A second imaging lens of 360-mm focal length focuses the image onto a rotating mirror which in turn reflects the image, using a 20-in. optical arm, onto a 4 × 5 in. photographic plate. Thus, a series of individual slit-width images of a fixed-space varying-time nature are produced. By moving the taking grid across the developed plate, a slit width at a time, successive frames are uncovered and may be viewed and measured. Using a grid with slit width of 0.0005 in. and a rotational mirror speed of 500 rps (with the 20-in. optical arm which produces a maximum image speed of 0.122 in./μsec), 2.5×10^8 frame/sec are produced; and with a 0.0001-in. slit-width grid, 1.25×10^9 frame/sec. At 10^8 frame/sec, the total exposure time for 30 frames is 3×10^{-7} sec. The camera described by Sultanoff is shown in Fig. 3, and is a modified Bowen RC3 Rotating Mirror Camera. A further redesign is in progress.

A device permitting exposures as low as 1-μsec duration at intervals of 2 μsec (500,000 frame/sec) was disclosed by Bartels and Eiselt in the German journal, *Optik*.[33] In this camera system, the image is focused upon a small mirror rotating at high speed and thence upon a series of stationary mirrors, from which it is focused upon stationary film.

During 1950, there was disclosed[34] the Zarem-Marshall Multiple Kerr Cell

Camera built at the Naval Ordnance Test Station, Pasadena, Calif. This camera is a further extension of the authors' work in electronic pulsing of a nitrobenzene Kerr Cell. An arrangement of three small Kerr Cells (which are pulsed in succession), imaging lenses and mirrors produces three images on a Speed Graphic Camera plate. The effective aperture of this system corresponds to $f/16$ and it has a total angular field of about 5°. The exposure duration may be varied, with effective exposure durations of 0.007 to 7 μsec stated to have been achieved. The interval between exposures can be made, it is said, as small as 0.01 μsec, equivalent to a frame frequency of 100,000,000/sec. An example of three exposures of the vaporization of a fine gold wire is shown with an effective exposure time of 0.04 μsec, and a frame frequency of 4×10^7 frame/sec. Pulsing circuitry and characteristics of the Kerr Cell and the nitrobenzene used therein are given.

Another Kerr Cell photographic instrumentation for ballistic photography was described by Quinn, McKay and Bourque[35] of the Canadian Armament Research and Development Establishment. In the study of ballistic phenomena, it was found necessary to photograph projectiles under conditions where the subject is either wholly or partially surrounded by a glowing medium of considerable luminosity such as a projectile striking armor plate or a projectile emerging from a gun muzzle. A system for synchronizing a gaseous-discharge tube and a Kerr Cell was devised to study these phenomena. The Kerr Cell provides for an effective exposure duration of the order of 2 μsec and operates at a peak voltage of 36 kv following previous German work. Super XX film and a flash tube, FT125, operating at 18 kv are used. Circuitry and results in ballistic studies are given in the report and a photograph of a 37-mm projectile taken shortly after penetration of a metal target plate is shown in Fig. 4.

A comprehensive study of a Kerr Cell for photographic purposes was made in England by Holtham and Prime.[36] The exposure time used was 2 μsec and provision was made for a variable time delay up to 0.1 msec. An aerial camera using an Ektar 18-cm $f/2.5$ lens, was modified to receive the Kerr Cell and 35-mm film. Image formation and photometric analysis were studied, and it was noted that the reciprocity curves of the emulsion show that the density obtained is not equal to that which would be obtained using the same illumination from a constant source. The transmission found through the system was of the order of 5% (50% for the Kerr Cell; 32% for each of the polaroid J films). Parasitic illumination, affecting the spectral quality of the light transmitted during application of voltage, was reduced by the use of an appropriate color filter. A rotating mirror and constant light source were used to illuminate the subject, the mirror being synchronized to the Kerr Cell opening. This Kerr Cell system has been employed in the measurement of spark channel characteristics, such as growth of the spark channel, its diameter and radial intensity variation across the spark.

The Kerr Cell has now evolved from a shutter for single-frame and three-frame high-speed still photography into a device for high-speed motion picture photography as described by Bowersox[37] of the Jet Propulsion Laboratory, California Institute of Technology. In order to increase the effective window area, a combination of three or more electrodes and a separation of sections of a single Kerr Cell has been used. At California Institute of Technology, a cell is being used with four separate sections, each section having three electrodes. An embodiment is described consisting of four Kerr Cell shutters mounted in a vertical line immediately in front of four lenses, in turn fixed close to the film held on a drum of 15-in. diam. The camera is shown in Fig. 5. The Kerr Cell

Fig. 4. Kerr Cell photography of a 37-mm projectile taken a short time after penetration of a metal target plate. (Courtesy of Messrs. Quinn, McKay and Bourque,[36] Canadian Armament Research and Development Establishment, Valcartier, Quebec, Canada.)

shutters are operated in sequence from top to bottom producing successive frames across the width of the film. Thus 620 frames, 0.3 in. square (roughly the same as 16-mm size) at a maximum speed of 50,000 frame/sec, are produced on a 4-ft long strip of 70-mm film. The cells are pulsed for only one drum rotation. Variable exposure durations are available of 1, 2, 3, 5, 6 and 10 μsec. The Kerr cells are operated on 12-kv pulses; the effective aperture for the system is $f/5$. The resolving power is said to be limited chiefly by the film motion (i.e., exposure duration), and secondarily, by the type of film used. A standard resolution chart mounted on a disk rotating at 10,000 rpm was photographed by this camera and shows a resolution of 14 lines/mm. At a frame frequency of 40,000/sec with an exposure duration of 1 μsec, the resolution is approximately 20 lines/mm.

A brief German paper[38] reviews some of the early work of high-speed photography including the work of Cranz who, in 1909, made a series of exposures at 5000 and, in 1912, at 100,000 frame/sec. A Kerr Cell producing exposure durations as short as 10^{-8} sec is described.

The development of the iconoscope

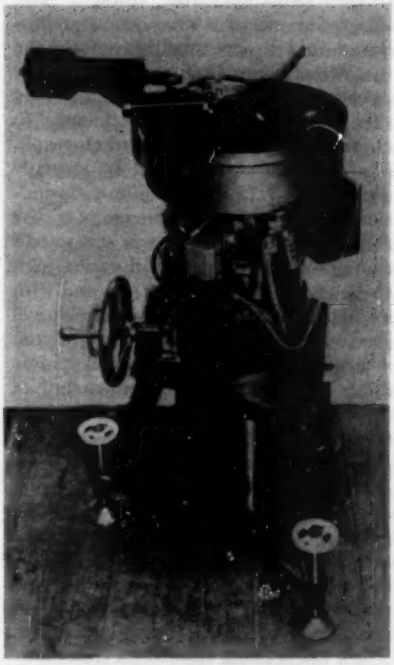


Fig. 5. Bowersox-California Institute of Technology (Jet Propulsion Laboratory) Very High-Speed Kerr Cell Motion Picture Camera. (Courtesy R. B. Bowersox.[37])

and the image orthicon (image converter tubes) as electrooptic shutters for very short exposure durations, holds a great potential for the future. Some of the initial work was carried out in England by Prime and Turnock,[39] Courtney-Pratt[40] and by others, and is also the subject of a paper to be given at this series of meetings by A. W. Hogan[299] of the Naval Ordnance Laboratory.

The use of the iconoscope as an electrooptical shutter depends on the storage characteristics of the mosaic. The electron image formed thereon by a transient phenomenon may be stored for a period of time before being scanned off by the electron beam of the iconoscope. A very short exposure period permits image formation and storage. The image thus stored is subsequently reproduced on a display tube by scanning the mosaic only once after completion of the phenomenon. The display tube may then be photographed producing, in effect, a high-speed still photograph. Nonluminous objects must be strongly illuminated. Using a medium-fast emulsion, a very satisfactory image of a disk rotating at 6000 rpm was obtained[39] during a 25-μsec exposure duration with the lens aperture open to $f/11$, and with an illumination of approximately 550 μsec duration. Using a faster emulsion, a larger lens aperture and an electronic light source of the same power but of shorter duration, exposures of 0.1-μsec duration have been readily achieved.

The inconoscope produces a secondary emission forming a ghost image and has tended to be replaced by an image orthicon which does not produce such secondary emission. However, with the image orthicon, a slight image diffusion results because of electron charges spreading onto adjacent mosaic elements. Spark phenomena have been studied by this technique. This system has certain advantages over the nitrobenzene Kerr Cell, and would seem to point the way to a most interesting future. (See also p. 458.)

Although high-speed still and motion picture photography have been applied in many studies, only a relatively few have found their way into the journals. Some of these are noted below.

In ballistics studies, a combination of streak photography and microsecond flash techniques accomplished simultaneously has been disclosed.[41] A 35-mm General Radio Continuous Film Camera was used to record self-luminous phenomena associated with the flight of particles produced by shaped charges: the velocity of the particles, variations in particle luminosity during flight, and the duration of burning of the eroded material. The smoke trail spatial distribution and its change with time, essentially nonluminous phenomena, are illuminated by means of microsecond flashes at a rate of 1000 flashes/sec. Similar techniques have been used in the past in connection with the simultaneous streak and image photography of gas-bubble phenomena in underwater explosion studies. In studies of this nature, the phenomena are not reproducible from shot to shot, and, hence, the data could not have been obtained by using these two techniques individually or in succession.

The released photographs of the first atomic explosion in New Mexico[42] were measured to determine the radius of the ball of fire for a large range of values of time measured from the start of the explosion. Energy in terms of equivalents of TNT was calculated, and two estimates of 16,800 tons and 23,700 tons were arrived at. The photographs were used also to measure the velocity of the rise of the glowing center of the heated volume of gas left behind and was found to be 35 m/sec. Other quantitative characteristics were determined.

High-speed still and motion picture photographic studies applied to the study of the airborne characteristics of underwater missiles were reported by Christie[43] of the Naval Ordnance Test Station, Morris Dam, Calif. In order to determine a torpedo's air velocity during free

flight prior to water entry, a multiple-image-recording "flare camera" is described. Several models of this camera have been produced, the latest employing a plane parallel glass plate rotating at 30,000 rpm, and producing multiple images in the form of a series of dots on a single photographic plate of two pyrotechnic flares attached to the tail of the test torpedo. Space-time information is reduced and velocities calculated.

The application of high-speed (short-exposure) photography to the rocket test program using Bowen-Knapp cameras with color film, was discussed by Elmer[44] in a paper delivered before this Society.

In the study of flame phenomena, a group at New York University[45] utilized high-speed schlieren motion picture photography.

High-speed motion pictures at frequencies up to 10,000 frame/sec were used[46] to study the process of deformation and rupture in tensile specimens of aluminum and brass at high strain rates. Most of the specimens broke too rapidly to be recorded by the camera, the break taking place in less than 10^{-4} sec. This break occurred in regular fashion along a line inclined at approximately 60° to the axis of the specimen.

The development of long a-c arcs, at currents of 46 to 6000 amp and lasting for 0.56 to 1.12 sec, was studied[47] by means of still and motion picture photography and by high-speed cinematography of the order of 1000 frame/sec. The deionization time of the arc was determined.

A Kerr Cell apparatus was set up to provide a series of superimposed photographs[48] in the study of the cathode spot of transient arcs using the liquid sodium–potassium alloy as the cathode. Quantitative behavior of this cathode spot with regard to current and under the influence of a magnetic field was studied. The interval between each exposure was varied and the number of exposures adjusted in order to show a complete picture of this phenomenon. The Kerr Cell was placed just outside a low-power microscope eyepiece.

The effect of arc-current gas pressure, kind of gas, and magnetic field on the motion of the cathode spot in a direction opposite to that predicted by Ampere's Law has been studied at the General Electric Research Laboratory.[49] High-speed motion pictures at 4000 frame/sec were employed to observe and measure the velocity of this phenomenon.

High-speed still photographs were used at the Hydrodynamics Laboratory of California Institute of Technology[50] to study regular and Mach intersection in hydrodynamic jumps. Hydrodynamic jumps were produced by two wave generators in a water table approximately 5 ft × 4 ft × 2 in. deep. The bottom of the tank was made of glass with a grid of known dimensions. A spark source was used below the glass bottom, producing a refraction pattern on photographic paper placed above the water surface. The resultant photographs are similar to the schlieren presentations of gas flows and permit measurement of associated phenomena.

High-speed still photographs taken of small spheres entering water vertically at various velocities were used[51] in the study of the virtual mass of such spheres. High-speed motion pictures were also employed to permit determination of space-time data for a series of spheres of various sizes and at various entry velocities. From the resultant acceleration data the virtual mass was calculated.

High-speed motion picture photography was also used quantitatively at 1500 frame/sec to determine the velocity of flow of blood in the basilar artery of the rabbit during the cardiac cycle.[52] The blood stream was made recognizable by the injection of a 0.05% fluorescein solution with emulsified olive oil.

High-speed motion pictures were used in textile research for the determination of the impact of raindrops on fabrics.[53] A Zeiss Ikon high-speed motion picture camera operated at frame frequencies to

6000 frame/sec was employed to determine the pressure–time relationship under such action. The velocity of the drops at the time of impact was measured from the film which was used to record two successive drops per roll. It was found that during impact, the upper parts of the drops retain their spherical shape while the lower parts are pressed outward as a continuous film. The upper part has about the same velocity as that of the drop immediately before impact. Some time thereafter, the drop breaks down into small particles and the second drop following on wet fabric was found to lose its spherical shape more quickly. The center of gravity of the deformed drop was determined and from this the pressure was calculated.

Applications of high-speed motion picture photography in textile processing research were disclosed by Fisher and Burnett.[54] The action of a shuttle in a production loom was studied as were the heddle action on an experimental loom, the traveler on a spinning frame, and yarn and cord breaks under laboratory conditions and during spinning of cotton yarn. It was noted that the traveler on a spinning frame would require frame frequencies greater than 5000/sec.

Other applications of high-speed motion picture photography included iron-making,[55] paper-mill maintenance,[56] and the analysis of vacuum cleaner mechanical components.[57]

C. Standard Still and Motion Picture Photography

The more orthodox still and motion picture photographic instruments and techniques have been adapted in several interesting ways for scientific studies.

A Kodak 35-mm still camera was adapted by Jean St. Thomas of the Civil Aeronautics Administration as a photographic transit for aircraft approach-zone studies.[58] A thin glass grid was placed in front of the focal plane; various grid lines represented horizon, glide-angle ratios, and the edges of the approach zone. Two camera stations were used and obstructions in the approach zone rapidly located and measured. A pinhole camera equipped with a focal-plane grid and mounted in the pilot's seat was also designed to permit direct-angle measurements of cockpit visibility characteristics.

A Cine Special operated at frame frequencies from 8 to 32/sec was used to record electron-microscope images.[59] The authors state that this is the first time motion pictures of electron-microscope images have been made. Motion picture studies of electron bombardment of various types have been made in conjunction with the development of electron microscopy by such workers as von Ardenne, Ruska, and others in Germany long before World War II. This technique has been used, according to the current paper, in the study of some of the effects of electron bombardment on colloidal crystals.[60] The viewing screen of the electron microscope is adjusted with its plane normal to the optical axis of the camera. The Cine Special is fitted with a 4-in., $f/2.7$ telephoto lens. A field of view of 30° is stated to be achieved. Super XX Negative film was found to produce the best contrast. At frame frequencies above 32/sec, the contrast was said to deteriorate. Resolution of 150 to 300 A is achieved. Some instrument adaptation is necessary to provide adequate illumination, and X-radiation must be guarded against. Solid–liquid–solid changes by recording Bragg reflections were investigated. A preliminary effect of electrons upon crystals is to drive off water. In salt crystals, a residual envelope is left in which small particles, both solid and liquid, are observed to move rapidly due, it is believed, to Brownian movement and convection. Tungsten oxide crystals and carbon black were also studied under an electron bombardment.

An application of multiple still photography in the study of size and charge of microscopic particles was described by

Kunkel and Hansen.[61] Horizontal electrical deflection of particles settling under gravity are recorded photographically. The rate of fall is measured and the Stokes' Law diameter calculated. It is also possible to calculate the approximate charge of the particles from the simultaneous electrical deflection. A strong dark field illumination is provided by an A-H6 high-pressure mercury-arc source with a baffle cutting out the central cone of the highly divergent light beam. Only light scattered into this dark cone is recorded on the film. A rotating disk, carrying four 6° openings (two or three of which may be closed according to the time intervals to be observed), is driven at 450 rpm. The intensity of the arc source fluctuates with 120 maxima/sec requiring alignment of the shutter disk in such fashion that maxima occur whenever an opening crosses the optical axis. A capping shutter for the camera is provided. A copper chloride solution is used to cut out about 95% of the infrared radiation of the source. Powder specimens are allowed to settle through a 3-ft settling column and enter a small analyzing chamber perpendicular to the optical axis of the lens and light source. To reduce heating effects, at most 30 flashes of 1/450 sec each, for a total exposure of 1 sec, are employed. Quartz crystals of sizes from less than 0.5 μ to 30 μ in various electrical fields were studied and trajectories measured.[62] In addition, charge distribution in coarse aerosols as a function of time were studied.[63]

Still photography has been applied to high-altitude rocket studies[64] to determine missile orientation, to make meteorological studies, and to investigate the possibilities of photographic reconnaissance from guided missiles. A K-25 aerial camera was modified to provide for greater acceleration than normally encountered in aerial photography and for insulation against low temperatures. Super XX and Kodacolor films were employed, with Kodacolor producing a deteriorated color image. Gun cameras using Kodachrome and Super X did not fare too well. A photographic method for the measurement of high-altitude orientation of rockets was developed.[65]

Orthodox photography has been applied to the determination of burning velocities of fast-burning mixtures.[66] Photographs obtained show two uniform flame speeds or speeds which vary from one uniform value to another due to changes in the orientation of the flame front. The photographs point out that the uniform motion may be compounded from these two speeds in any proportion and, therefore, suggest that electrical methods for determining flame speeds yield results which are not necessarily reliable.

Motion picture photography was used to study the convection currents near a carbon arc through photography of carbon particles moving in a dark field near the arc column.[67] From these results and a knowledge of the spatial temperature variations, the convective heat loss from the arc channel may be found and compared with the electrical energy input.

Time and motion study techniques employing motion picture photography continue to produce useful results in such matters as method analysis,[68] the setting of performance levels,[69] and training of personnel to better utilization and reduced time and effort.[70]

D. Cathode-Ray Still Oscillography

Several still cameras designed for oscilloscope trace recording were announced during 1950. Moving-film-type recorders are not discussed in this section, but under *E*, below.

DuMont has brought out three still cameras for oscillographic recording. Type 297 consists of an oscilloscope hood carrying an $f/2.8$ 75-mm lens, a variable-speed shutter, and a Polaroid-Land Camera back. The writing speed is said to be to 1 in./μsec for the $f/2.8$ lens, and to 2 in./μsec for an $f/1.9$ lens which

may be procured separately. An illuminated data card may be recorded on the film. The DuMont Type 296 still camera for oscillographic recording consists of a Bolsey-type camera, an $f/2.8$, 41.5-mm lens, and is said to provide a writing speed of more than 10 in./μsec with a Type 5RP-A cathode-ray tube operated at 12,000 v. A variable-speed shutter and a means for simultaneous viewing is provided. The third camera DuMont offers is their Type 295 fitted with an $f/1.5$, 50-mm lens. Thirty-five millimeter perforated or unperforated film or paper of 36-exposure length in the standard cassette may be used. A light-tight take-up cassette with a built-in cutting knife is provided for short-run operation. It is said that writing speeds greater than 35 in./μsec are possible with the Type 5RP-A cathode-ray tube again operated at 12,000 v. DuMont states that the $f/1.5$ lens will permit the recording of traces at writing speeds as high as 80 in./μsec and that an $f/1.0$, 2-in. lens is also available. The shutter may be operated manually or by a solenoid, and provides time and bulb exposures. A data card may be recorded on the film.

The Fairchild Camera and Instrument Corporation has also brought out a Polaroid-Land Oscilloscope Camera[71] fitted with an $f/2.8$, 75-mm lens, a variable-speed shutter, and provision for two images per $3\frac{1}{4}$-in. × $4\frac{1}{4}$-in. frame, or a total of 16 exposures per roll of film. At 3000 v, writing speeds to 1 in./μsec may be recorded.

A number of papers were presented concerning the elements of cathode-ray oscillographic recording.[72–75] Calibration lines and a data card are recorded on the same film as the cathode-ray-tube-image by a newly devised system.[73] Notations are marked on a paper mask surrounding the cathode-ray screen. Fine wires are used to construct a calibrating grid and both are illuminated by a light source between the camera and the cathode-ray oscillograph.

Fraser and Badgley of the Naval Photographic Center[76] have recorded color television images at 24 frame/sec. A 16-mm Mitchell Motion Picture Camera was fitted with a Polaroid $f/0.7$ lens for recording color television broadcasts at 24 frame/sec using a 177° shutter. A Berndt-Maurer 16-mm Camera with a fixed 180° shutter and an $f/1.4$ lens was used to record both color and black-and-white telecasts. CBS, RCA, and CTI color television presentations have been recorded with various camera and lens combinations.

Cathode-ray still photography has been applied to the measurement of vertical and horizontal growth and propagation of a thunderstorm from sequence photographs of the PPI and RHI presentations of such a storm in its initial precipitation stages.[77] Rapid vertical growth after a first precipitation was detected and uniform horizontal growth observed.

E. Continuously Moving Film and Image Systems

A photographic method used in England for the recording of displacement versus time phenomena was described.[78] Small spherical reflectors are attached to, or formed upon, the surface of a moving body, producing point images of a fixed light source. Thus, the point source-image moves with the body under study and by recording its motion with a continuously moving film or rotating drum camera, a time-displacement record is obtained. The record takes the form of a fine, sharply focused, continuous line from which space-displacement measurements can be made. It is possible to carry out such photography under normal lighting conditions. The camera described in this paper gives time scales in the range of 0 to 315 in./sec. This technique has been applied quite extensively in this country to shock, vibration and explosives studies.

In connection with shock and vibration studies, Vigness and Nowak,[79] of the Naval Research Laboratory have de-

scribed a modification of the standard streak-photography technique. Small reflectors such as ball bearings have been used in orthodox streak photography in a manner similar to that described above. However, a source of error in the standard streak-photographic method lies in the possible motion of the object in a direction parallel to film motion. The modified streak method of Vigness and Nowak was devised to eliminate this error, to permit measurement of large displacements and to obtain an accuracy within a few thousandths of an inch. The object photographed consists of a series of white lines an equal distance apart, marked on a dark background. These lines are in a plane perpendicular to the direction of film motion. The direction of motion of this object, rigidly attached to the part under study, should be perpendicular to the camera optical axis and to the direction of film motion. The camera lens will focus an image of these lines on the film. A cylindrical lens, on the plane surface of which is a slit parallel to the direction of object motion, is placed just before the moving film and perpendicular to its direction of motion in order to focus these lines to approximate points. Motions of the objects in a direction parallel to the film motion will not result in any displacement of the image on the film. Small rotations in a plane perpendicular to the camera's optical axis will produce second-order errors, and motions out of this plane will result in the usual scale changes in depth-of-focus problems. This technique has been used to study displacement of many inches measured to an accuracy of a few thousandths of an inch, and to 10 μsec.

DuMont announced a continuously moving film camera, their Type 321, which is characterized by a 400-ft capacity of 35-mm film or paper, and a range of linear film speeds from 0.82 in./min to 15 ft/sec, in 18 fixed increments.

The Lydiate Ash Laboratories in England exhibited their Type 200 continuously moving film camera. This camera, representing a thorough and fundamental design approach, provides, through a gear box having a 60 : 1 change of speed (which can be obtained with the camera in operation), film speeds from 3 in./min to 120 in./sec. Full electronic motor control is employed. Other features are a 400-ft, 35-mm film capacity in interchangeable magazines; a built-in timing marker; provision for photographic data cards; and push-button operation through interlocking relays. A higher-speed version, providing to 40 ft/sec, has also been exhibited.

An interesting French camera, a high-efficiency streak camera, was described by Malan[50] for studying the correlation between the optical and electrical effects of lightning strokes. The camera produced combines advantages of other previous devices such as drum recording and ease of film changing. The film remains stationary, while the optical system is mounted in a rotating drum. Beside a reflecting prism and an objective, a Wollaston prism mounted between these is given an epicyclic rotation at half the speed of rotation of the drum. This counteracts the rotation of the image around the reflected optical axis. A few modifications make this apparatus suitable for the recording of oscillograms of transient phenomena. The apparatus carries 100-ft of 35-mm film, permitting 23 successive exposures. The only adjustment necessary between exposures is the rotation of a handle which winds the film to the next unexposed position. The objective is a 50-mm, $f/2.8$ lens, and rotation of the optical system is carried out at a speed of 510 rpm. The film exposed during photography, upon the opening of an electromagnetic shutter, is 112 cm long, and the linear speed of the image is 952 cm/sec.

A technique for time and motion study was described, in an English journal,[51] in which time-displacement information is recorded on a single plate. In certain time and motion study work, it is possible

to employ small light sources affixed to the object under study, such as the hands of an operator. In subdued light, the operator goes through his prescribed motions using an orthodox still camera with the shutter open. A pair of traces formed by the light sources is thus recorded on the film. In the technique disclosed, essentially a modification of a system employed by Gilbreth many years ago, the lights attached to the worker's wrists are pulsed at a known time interval permitting the reduction of space-time information.

The mechanism of detonation has been studied by Pike[82] through the use of high-speed mirror cameras having writing speeds of from 1 mm/μsec to over 4 mm/μsec. By electronic means, writing speeds of 24 mm/μsec have been achieved. Similar work was reported by Johansson[83] who used a rotating-mirror camera having a writing speed of 0.9 mm/μsec for measuring the velocity of the air-shock wave from the flat end of a cylindrical stick of explosive. The detonation velocity for the explosive (60% PETN and 40% TNT) was found to be 7400 m/sec. As the air pressure decreases, the shock wave velocity increases; at 2 cm from the explosive face at normal atmospheric pressure this velocity was 6500 m/sec, while at 0.5 mm of mercury it rises to 17,500 m/sec.

A series of rotating mirror cameras used as streak cameras for the study of explosive phenomena was reported also by Evans,[84] Davies, Owen, Edwards and Thomas,[85] and Adams,[86] reporting, respectively, on cameras having writing speeds up to 1 mm/μsec, 4 mm/μsec, and 4 and 6.5 mm/μsec. The latter two cameras are of particular interest. In the 4-mm/μsec camera, provision is made for the simultaneous observation of a vertical and a horizontal slit; the image of each slit is traversed along an independent quadrant (track radius, approximately 19 in.) by means of a 2½-in. square section mirror, rotating at 40,000 rpm. By means of interchangeable objectives, distances from 20 ft to infinity can be covered. The film width is 90 mm, of which 2.75 in. is available for recording. The output from a magnetic pickup on the mirror shaft is fed to a tachometer circuit which measures the speed of rotation of the mirror. The same circuit is used to provide the firing impulse which initiates the charge, thus insuring that the record appears on a predetermined position of the film. In the 6.5-mm/μsec camera, a laminar rotating mirror, 1½ in. × 1 in. × 0.1 in., is driven by compressed air at a speed of 80,000 rpm. The mirror speed measurement and the event synchronization for this camera are similar to those for the 4-mm/μsec camera, but an additional time device is provided in the form of three spark gaps inside the camera body, triggered at known intervals during the recording period.

An additional use to which the image-converter tube has been placed was reported by Courtney-Pratt,[87] the device producing a record similar to that from a rotating-mirror camera. In this case, the cathode image is restricted to a narrow slit. By this method, writing speeds of 100 mm/μsec have been obtained with a time resolution better than 10^{-9} sec.

A continuously moving film camera, having a temporal resolution on the film of 1.5 mm/μsec was used in England by Higham and Meek[88,89] for the determination of the lengths and the rate of expansion of long gaseous spark channels during the first 10 μsec of their growth. Measurements were also made with the rotating mirror scanning an image of the spark across a photomultiplier connected to a high-speed oscillograph to provide radial light distribution across the spark channels. Sparks of various peak currents in air, N_2, O_2, and H_2 at atmospheric and reduced pressure were investigated.

Kock and Harvey,[90,91] of the Bell Telephone Laboratories, employed a Polaroid-Land Camera in a darkened room to photograph sound waves which are portrayed by a small lamp moving up and

down as the lamp progresses in successive planes across the sound field. The intensity of the light is varied automatically in accordnce with the sound level as determined by a small microphone attached to the lamp. The properties of sound-focusing systems have thus been investigated. By this method, sound-field mapping is obtained with a fixed photographic plate and a continuously moving subject.

F. Data Recording

There has been a considerable impetus in the development of data-recording cameras. Essentially based upon the requirements of aircraft design, the British Auto Camera, introduced several years ago, was the subject of a 1950 paper.[92] This camera permits the taking of 200 exposures, 1 in. square, on approximately 18 ft of 35-mm film. The camera has a spring-wound motor of a design permitting all 200 exposures to be made on one winding and an electrical release for remote control which trips the shutter and releases the spring for advancing the proper amount of film. This camera comes equipped with a 36-mm, *f*/3.5 lens of special design which covers about 35° of angular field. A variable-speed shutter permits frame frequencies up to 4/sec. The camera is $8\frac{7}{8}$ in. long by $3\frac{3}{8}$ in. wide by $3\frac{1}{2}$ in. high. It is operated on 24 v d-c, and weighs, with film cassettes, $5\frac{1}{2}$ lb. An electrical contact is incorporated which can be used to operate an exposure indicator or a discharge lamp.

A Swiss 35-mm gun camera, the Euram, was introduced in 1950.[93] This camera operates on 24 v, and provides for single-frame exposures at predetermined intervals, or motion picture frequencies at 24 frame/sec. This camera carries 112 ft of 35-mm film in a detachable magazine which is provided with an automatic loop former. The overall dimensions are approximately $5\frac{7}{8}$ in. high, $5\frac{1}{8}$ in. wide, and $16\frac{3}{4}$ in. long, and the camera weighs approximately 12.2 lb in the loaded condition. Four lenses may be used interchangeably, and the rotating shutter has a 160° aperture. The film is advanced by a positive claw movement alternating with a positioning pin.

The Automax 35-mm data-recording camera, built in this country by Guild Laboratories of Los Angeles, was announced. This camera can be operated locally or by remote control, under single-frame operation with an external intervalometer from 1 exposure/hr to 5 exposures/sec, and under motion picture operation either 12 or 16 frame/sec. Film exposure duration is the same for both interval and cine operation. This camera is fitted with a standard 400-ft Mitchell Magazine for 35-mm film, but other capacities are available. The Automax is designed for aircraft accelerations. A film-driven switch actuates an electrical footage counter, and also gives remote indication of camera operation. A variety of motors is available for various field or mobile applications. The camera without magazine measures 6 in. × 5 in. × $2\frac{1}{4}$ in., with the motor extending from 2 to 3 in. beyond the $2\frac{1}{4}$-in. dimension. The weight, with aircraft motor, loaded 400-ft magazine, and lens, is 12 lb. The camera is designed for an operating temperature range of −40° to + 160 F.

Another data-recording camera, the Fairchild-North American Aviation Camera, was briefly described in the "New Instruments Section" of the *Review of Scientific Instruments*.[94] This 35-mm data-recording camera, mounting interchangeable Mitchell Magazines of 400-ft or 1000-ft capacity, features remote selection of 4, 8 and 16 frame/sec, with constant exposure rate at 1/50 sec at any of these frame frequencies. In addition, single-frame operation, either manually or by intervalometer, is possible. This camera has been designed to operate at a vertical acceleration range of −2 to +2 *g*, at a temperature range of −40 F to plus 160 F, and at altitudes up to 60,000

ft. Optional power requirements are 28 v or 110 v. Somewhat higher frame frequencies are available in a special model. The camera size is $14\frac{5}{16}$ in. long by $8\frac{3}{4}$ in. wide by $15\frac{1}{4}$ in. high. The weight of this camera, with 400-ft magazine is approximately $26\frac{1}{2}$ lb. A 25-mm lens is regularly supplied.

The Cook Research Laboratories disclosed their Model A-1 Data Recording Camera,[95] which provides for remote single-frame data-recording photography at frame frequencies up to 4/sec. This camera has a magazine carrying 200 ft of 35-mm film with a built-in Geneva-type intermittent. A 50-mm, $f/1.4$ lens is normally supplied. The shutter is completely open within 20 msec after the start of the electrical tripping impulse. Shutter speeds can be set at the factory at a predetermined value of from 1/200 sec to 1 hr, or can be furnished as a variable type from 1/200 sec to 1 sec. Both types can be furnished with provisions for holding the camera shutter open for the duration of the tripping impulse. Film transport which takes a maximum of 75 msec, occurs immediately after the cessation of electrical tripping impulse. The camera can be furnished to produce either single- or double-frame size records. The voltage required for the standard camera is 24 v d-c. The dimensions of the camera are approximately 11 in. × 12 in. × $6\frac{1}{2}$ in., and it weighs approximately $10\frac{1}{2}$ lb.

The Flight Research Engineering Corp, has produced a modification of the 16-mm GSAP Camera, their Model III,[96] permitting synchronous operation of a multiplicity of such cameras. The Standard Model III Camera operates at 10 frame/sec at an exposure time of 1/100 sec. Change gears are provided for 5 frame/sec and 20 frame/sec with an exposure time of 1/50 and 1/200 sec, respectively. Fifty-foot magazines of 16-mm film of the Syno-Pack, AN-A6, or Type G varieties, may be used. Another model may be supplied providing 4, 8, 16 and 32 frame/sec. Synchronous recording of images in a multiple camera chain to a shutter divergence of 5° maximum among all cameras is claimed. Flight Research Engineering Corporation has also disclosed a 35-mm counterpart of the above-mentioned camera, their Model IV, which is also designed for synchronous data recording using a multiplicity of cameras. Shutter accuracy is said to be maintained, among all cameras in a chain, to a maximum divergence of approximately 5°, or 1/700 sec at 10 frame/sec. "Master-slave" operation, single framing, fiducial marks and other characteristics of the 16-mm camera obtain. This camera utilizes standard 100-ft daylight-loading 35-mm film spools, and has the coding and timing marker lamps and the same frame frequency selection as the 16-mm Model III. This camera measures approximately $5\frac{1}{2}$ in. × $8\frac{7}{16}$ in. × $5\frac{11}{16}$ in.

An airborne synchronized motion picture system was described by White and Horwitz[97] of Northwestern University. Thirty-five-mm Eyemos fitted with 1/95-hp d-c motors, and 16-mm gun cameras driven by flexible shafts from separate drive units were operated at 20 frame/sec, one such unit driving two 16-mm cameras. A synchronization system said to be capable of producing shutter synchronization within one aircraft at frame frequencies of 20 frame/sec to within $\pm$ 0.002 sec is disclosed. Oscillographic recording for monitoring the accuracy of the motor control system, film coding for marking the film of different cameras for matching, a timing system relating all data to an accurate time base, and a plane-to-plane radio link for control equipment and relating data between two or more aircraft are part of this system. Phase differences between the cameras of two aircraft may exist, but the difference can be determined from the oscillograph records, as can the actual time of shutter openings for all cameras to 0.001 sec. Seventeen cameras were operated in the remote aircraft, and six in the parent. Gaseous-

discharge tubes were used to provide short-duration illumination of fast moving dials.

There appears to be considerable requirement for a more accurate synchronization and more insurance of frame-to-frame matching than exists in the systems described above. Work in this direction is currently under way and synchronization to better than 1° of shutter rotation is expected.

An automatic flight data-recorder for photographically recording instrument readings in aircraft during test flights was developed by Edgerton, Germeshausen, and Grier.[55,95] Electric motor drives were adapted to the standard 16-mm magazine Cine Kodak. Fast acting, overriding shutters were incorporated to give a short exposure despite the slow operating speed of one frame per second. Contact synchronizers with zero time delay were incorporated for synchronizing the electronic flash provided by a special gaseous-discharge tube utilizing only its infrared radiation. The instrument panel illuminated measures 11 in. × 14 in. The camera-to-panel distance is 36 in., the maximum aperture is *f*/1.9, and a 12-v battery source is used. The complete unit, which includes power supply, camera, lamphouse assembly and cables, weighs 18 lb. The lamphouse is covered with a Wratten 88-A filter, and is mounted directly on the camera. The camera lens is covered with a Wratten 88 filter, and infrared film is used. An input to the flash tube of 12- to 14-w sec is provided.

A modified Bell & Howell Filmo camera is used to determine space-time information in the study of aircraft takeoffs and landings.[55] Two 16-mm frames are recorded simultaneously, the upper portion carrying an image of the aircraft, and the lower, a series of instrument recordings giving information in the form of time, position of an azimuth scale, a wind velocity indicator, a wind direction indicator, a data card, and a film footage counter. A 4-in., *f*/4.4 lens is utilized interchangeably with 6-in., 10-in., or 12-in. lenses. Azimuth scale objectives are changed, depending upon the focal length used. An exposure of 1/200 sec at a frame frequency of 4/sec is characteristic of this camera. Satisfactory operation is said to be possible from −20° to +140 F. The capacity of this camera is 100 ft of film and the azimuth scale covers 146.6° of arc. The azimuth scale is set with the zero normal to the flight path, and the camera is panned in photographing the landing of the aircraft. A two-camera setup may be employed if the aircraft is not following a standard flight path normal to the zero of this azimuth scale.

Another space-time data-recording camera was designed by Neyhart of Guild Laboratories, similar in conception to the camera described above. This Photo-theodolite takes pictures at 0.1-sec intervals, and is provided with a glass grid of horizontal and vertical degree lines which are superimposed during exposure on a series of pictures of the takeoff and landing of the aircraft. The grid, in the form of a 160° segment of a circle, is provided with five horizontal lines, each representing 2°, and vertical lines, each representing 1°, recording to 80° either side of a 0° marker. By orienting this 0° mark at a known distance on a line perpendicular to the flight path, and locking it in place, the camera, which is free to rotate about the center of the lens, is used to record the aircraft characteristics under study. A special coaxial, double-drum shutter, situated between the lens and the film plane, makes one exposure per revolution. Reduction of data from these records, producing linear distance of airplane travel, is quite simple. By multiplying the tangent of the angle recorded on the film by the distance of the Photoscope Camera from the line of flight, the distance of the airplane from the intersection of the perpendicular camera line is determined. The dif-

ference in these two distances derived from any two consecutive frames is the distance traveled by the airplane in 0.1 sec. This type of photographic theodolite is finding considerable use in flight test programs.

G. Data Reduction Apparatus

Reduction of data from film has not received the impetus due it, although some progress was made in 1950.

Several instruments were announced of use in nuclear research. One is used in studying stereoscopic cloud-chamber photographs. In this device, described by Bromley and Bradfield,[99] the stereoscopic photographs are obtained by two modified 35-mm still cameras which are electrically operated. Means are provided for accurate location of the film in the focal plane. This two-camera unit is mounted in a replica of the chamber with the cameras' optical axes horizontal. A 10-in. × 12-in. ground-glass plate screen, free to rotate about a horizontal axis, is mounted on a movable base. Magnetic clamping devices permit orientation of the camera unit and screen to any desired orientation. Alternatively, a 12-in. circular enameled metal screen may be used. The screen may be rotated in all directions. The films are replaced in their respective cameras after processing and illumination sources fitted to the cameras. For each frame, the screen is moved to put the image of the top and bottom of the chamber into coincidence, and the distances from the film planes to the screen are adjusted to their original distance. With film positioning thus checked, angle and range measurements are made directly on the screen surface. Photographic records may also be made by placing a photosensitive material on the screen for the necessary exposure duration. To compensate for distortion caused by the plate-glass cloud-chamber roof, a similar plate is inserted at the proper point between screen and cameras.

A semiautomatic device for data reduction of nuclear phenomena was constructed at Columbia University and reported upon in the *Review of Scientific Instruments*.[100] In this apparatus, a microscope is fitted with a motor-driven stage which is moved by selsyn motors in x and y directions. The accuracy of this movement is said to be measurable to within 0.2 μ. These selsyns are fed from identical selsyn generators which are driven by a steering unit so that the photographic plate under study can be moved in any direction and with any desired speed up to approximately 25 μ/sec. The operator controls the direction and the speed of motion by a steering wheel and an accelerator pedal, and drives the nuclear track to be analyzed through a target. A recording-chart system, with the chart moving at 2000 times the speed of the microscope stage, permits the automatic recording of range, grain density and geometrical orientation of the tracks; 2 millimeters on the chart correspond to 1 micron on the photographic plate. The image of the plate is observed by the operator through an eyepiece and, at the same time, projected upon a small slit before a photomultiplier tube. The chart also records the angular position of the steering wheel and the vertical movement of the objective. Three-dimensional information may be deduced. The smallest slit reported upon is 1 mm long by 0.03 mm wide, covering an area on the plate of 0.07 × 0.02 μ (for a 2-mm immersion objective). Direct photometric comparison of the track against the surrounding background is possible where the accumulation of grains in the track is too heavy to be analyzed by counting individual grains. The method is said to produce reproducible results and a grain density record for a 2000-μ track may be made in about 10 min. Determination of coordinates may be accomplished with good accuracy.

A projector unit has been developed in Canada,[101] in which the film advance sprocket is driven by a reversible motor

and a glass pressure plate, holding the film in the projection plane, is released automatically while the film is being moved. The film spools accommodate 100 ft of 35-mm film, and take-up slack in both directions. Multiple record correlation may be accomplished by the use of several such units simultaneously.

One of the axioms of photographic instrumentation is that data should be recorded on film in such a form that rapid and accurate data reduction is possible. A device embodying this principle has been described by Benson[102] of the Douglas Aircraft Co. Information, such as telemetered quantities, is recorded on film in the form of a line perpendicular to the direction of film motion. The discrete value of the particular quantity is reported by the length of this line and a device has been built to permit automatic measurement of these lines, calibration of values, and plotting to suitable scales. In this device, 28 channels representing the readings from 28 instruments in a guided missile, for example, are recorded in a 35-mm continuously moving film camera. Thus, each frame consists of 28 parallel straight lines, each the recorded image of the motion of a light spot appearing on a cathode-ray tube. About 32 such frames are recorded per second. The automatic analyzing machine counts progressively through a frame to locate the required line, measures its length, and plots the associated value after suitable modification by preset 0 and scale factors. About 40 points are plotted per minute with an accuracy said to be better than $\pm\frac{1}{2}\%$ of full-scale deflection. The device embodies some 14 memories for calibration purposes, and about 5 distinct sequential thought patterns for selecting lines, controlling measuring cycles, and so on. In addition, some 5 discriminative thought patterns are involved to detect errors. A film projector and screen, using a photoelectric cell, counting circuits and electronic measuring networks, accomplish the reduction. This device normally plots six channels through one run of the film through the machine, and six different colors are used for the resultant plot. It is stated that an experienced operator can adjust the machine in about 15 min. A man-hour ratio of more than 5 to 1 in favor of this automatic method over previously employed manual data-reduction techniques was said to show a saving of over $9000.00 for a single record.

A device which permits automatic selection of microfilm frames and automatic photographic copying has been developed.[103] For such applications as literature research, microfilm copies of papers are photographed together with a code consisting of a series of light and dark squares. A scanning device, preset to react to a given coding, rapidly picks out the desired frames, and photographs them by means of a gaseous-discharge tube flash on 35-mm film. In this fashion, a single microfilm roll containing all papers on a given subject may be produced in a minimum time.

H. Shadowgraph

Shadowgraph instrumentation has long been employed for aerodynamic studies. Several embodiments of this technique were disclosed in 1950.

The pressurized ballistics range at the Naval Ordnance Laboratory[104] consists of a steel tube 3 ft in diameter, and over 300 ft long. Pressures from 1/100 to 5 atm may be employed in this tube. Twenty-five photographic stations, each fitted with a light screen and photocell, were designed to initiate a microsecond spark flash. The missile's shadow is recorded directly on a vertical photographic plate and on a similar horizontal plate by means of a mirror. Fiducial marks permit accurate coordinate determination. The duration of the spark source is said to be of the order of 0.5 μsec and it is of high intensity. An electronic chronograph is used to measure the time required for the missile to pass between two stations, measuring inter-

vals up to one second with an accuracy of the order of 0.1 μsec.

The second ballistics range reported on is that for the study of rockets at the Naval Ordnance Test Station, Inyokern.[105] A new type of silhouette procedure is employed for the determination of position and orientation of rocket models in transonic and supersonic flight. Measurements on the photographic plate to within $7\frac{1}{2}$ μ were found to be necessary. A multiple flash stroboscopic lighting technique using gaseous-discharge tubes and low-cost reflex reflectors for improvement of image-background contrast are employed.

Space-time data are being obtained in the Supersonic Free Flight Wind Tunnel at the Ames Aeronautical Laboratory[106] by means of a four-station shadowgraph and an associated chronograph. As the model flies by each station, a light screen initiates the spark-flash recording of the missile in flight on photographic plates. Some of the spark source light is recorded on a separate 35-mm chronograph. At the same time, an H-6 mercury lamp is pulsed at any desired frequency from 10,000 to 100,000 cycle/sec to provide a time base. Fiducial marks permit coordinate measurement. In addition to these four shadowgraph stations, three lateral photographic stations make possible the reduction of the three-dimensional flight path. From this flight path, lateral and vertical accelerations, hence side force and lift, can be obtained. Other quantities may be deduced.

Shadowgraphic techniques were employed at Naval Ordnance Laboratory to study the characteristics of water entry of spherical missiles at supersonic speeds.[51,107] Missiles shot into water at velocities of 7000 ft/sec were recorded at exposure durations of less than a microsecond.

Normal burning velocities of propane-air flames have been measured from shadowgraphs.[108] The previously employed stroboscopically illuminated-particle method of measuring the normal burning velocity by the heat capacity of the particles is said to be limited. A supplementary method is used to define the flame area. The line between the dark and light spaces on shadow photographs taken at different distances from the film to the flame defines this area, which is then extrapolated to the diametral plane of the flame.

I. Schlieren

Considerable activity in the improvement and extension of the schlieren system was reported in 1950.

A system employing multiple slit-gratings replacing the conventional knife-edge elements was described by Mortensen[109] of the Midwest Research Institute. A number of advantages are claimed, particularly that larger-sized working fields can be achieved with an objective lens of given aperture. Greater intensity of image illumination is obtained in some cases, and usually the overall length of the system can be reduced.

A variable-focusing schlieren system was developed at Cornell University,[110] which is able to distinguish between the density gradients occurring at various positions along the light path. This schlieren system utilizes multiple light sources and corresponding cutoffs to achieve this variable-focusing effect. The source plate has 82 slits, of which about 50 are illuminated, while the cutoff plate provides for 82 corresponding knife edges. Each source-cutoff combination produces an independent schlieren image, and for a given screen position, the shadows produced by density gradients at a single plane in the field superpose exactly. In general, for planes out of focus, offset superposition of the images blurs out the effects of density gradients not in the focal plane by a process similar to the focusing of ordinary lenses. This system has not been very effective in studying boundary layer phenomena.

A conventional schlieren system employed in connection with a shock tube for the study of two-dimensional wave

propagation was reported upon by Cornell University staff members.[111] A spark source discharged 1.7 μf (microfarads), charged to about 9 kv, for an exposure duration of the order of 1 μsec.

A French governmental laboratory[112] has reported upon its schlieren system used for the study of supersonic flow. This system comprises essentially a controlled-arc source of light, and a double field lens (diameter, 21 cm, focal length 1.5 m) producing an image which is shielded from the light source by a screen having almost the same dimensions as the image. A projection objective is used to obtain an image of the surface to be studied on a screen between the field lens and the primary image. Cinematographic recordings have been employed.

The Langley Aeronautical Laboratory, NACA, has reported[113] on its schlieren and other flow visualization techniques. Their experience with the 11-in. wind tunnel indicates that the limit of usefulness is reached at a pressure of about 1 mm of mercury for slender test models at M = 7.0. At these conditions, good results have been achieved by the use of a double-pass system which has proven of use at M = 10 for a 50-atm (atmosphere) stagnation pressure. For higher tunnel speeds, the nitrogen afterglow technique[114] has been employed. Schlieren afterflow photographs have been obtained at low pressures. Examples of applications of schlieren systems to various aerodynamic flow studies are given.

High-speed schlieren motion pictures were used at New York University,[45] together with instantaneous pressure measurements, to study flame structure and flow in half-open tubes. The high velocity flames were produced by placing a grid augmenter in the path of an advancing flame front. Frame frequencies in the Fastax range were employed.

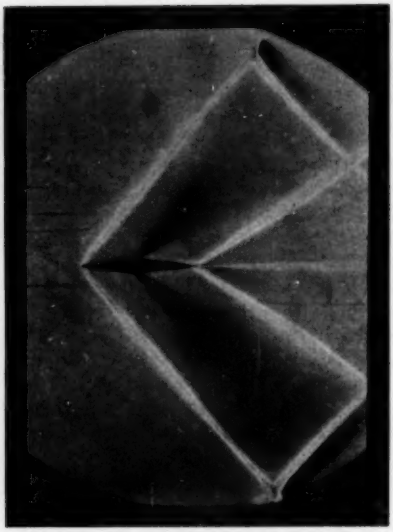
In other flame studies,[115] schlieren photography has been used to measure the spatial velocities of flames moving in mixtures of nitrogen dioxide and formaldehyde, at initial pressures of 4 to 8 cm of mercury in a spherical vessel.

The schlieren technique has also been applied[116] to the measurement of radial variations of gas temperature in arcs. Currents varied from 2.9 to 20 amp, and the gas temperature was 4000 K at about 4 mm from the discharge axis, falling to about 200 K at about 2 cm.

The use of a phase plate replacing the knife edge in a schlieren system for use in microscopy has been extensively investigated.[117–119] Improved sensitivity is said to result.

Considerable interest has been shown in color schlieren systems. The conventional schlieren system, recording only brightness, is affected only by the components of the deflection at right angles to the knife edge. With a color schlieren system,[120] using an illuminated color circle in place of the slit, and a circular aperture in place of the knife edge, the hue and saturation of an image will indicate the direction and magnitude of the deflection. This system has been applied to microscopy.

The National Physical Laboratory at Teddington, England, has disclosed[121] a color schlieren system found to be useful for flow investigations in a high-speed wind tunnel. Using the standard off-axis schlieren system, a white-light source is dispersed by a prism, and the parallel beam of light passed through the working section. A plane mirror is used in connection with a slit and camera lens to bring the color schlieren image to focus on a photographic plate. The image of the source thus formed ahead of the slit consists of a series of colored bands and the slit, placed in the focal plane, is adjusted to cut off all the light except that of a particular color. When the density gradient in the working section is uniform, the image on the screen is monochromatic and uniformly illuminated. But, with the introduction of schlieren, the corresponding image of the source shifts relative to the slit, and the corresponding part of the image on the



Figs. 6 and 7. Black-and-white reproductions of color schlieren photographs showing flow around a 12% double-wedge aerofoil at a Mach No. of 1.6. The originals were made on 35-mm Kodachrome. (Courtesy of R. J. North,[121] Aerodynamics Division, National Physical Laboratory, Teddington, England.)

1. Background—yellow
2. Light to dark gray areas—green
3. Leading and trailing shock waves—dark orange

1. Background—green
2. Light to dark gray areas — blue
3. Leading and trailing shock waves—yellow

photographic plate changes color. Good results are said to have been obtained using a 48-w projector lamp as the light source. The quantitative use of this system may be achieved by moving a slit across until a particular color disappears from a point in the image on the photographic plate, thus determining the displacement of the corresponding image of the source in the focal plane of the second mirror. Figures 6 and 7 are color schlieren photographs presented through the courtesy of the National Physical Laboratory.

Another color schlieren system producing quantitative results has been disclosed.[122] This system utilizes a dispersing prism to illuminate the field, and a slit in place of the usual knife edge. The normal field will then be colored and any deviation will be shown as a change in this color. If a second dispersing prism with its axis at right angles to the first is placed near the image plane, deviations will be recorded as small spectra whose lengths are a measure of the deviation. Using a source with a number of discrete spectrum lines, the schlieren field will show colored contour lines whose deviation can be found from the known wavelengths.

J. Interferometry

Interferometric methods have proven of particular interest in the study of aerodynamic flow and are finding other applications as extensions of earlier work in such fields as the study of metals, surface polish, hardness testing, and the formation of slip bands in stressed metal-

lic crystals.[123] This latter technique of multiple-beam interferometry has also proven of use in the study of thin-film thickness measurements,[124, 125] and indicates utility as a stage micrometer.[126, 127] It has also been used in studying the mechanism of crystal growth in certain minerals, the examination of defects in mica, and the modes of oscillation of quartz.

In aerodynamic investigations, a modification of the standard Ronchi schlieren two-mirror technique has resulted in the development of a new, low-cost, large field diffraction grating interferometer.[128] In this system, a monochromatic source and a pair of replica transmission gratings (2000 lines/in.) are used in conjunction with the standard two-mirror schlieren system, with the diffraction gratings placed axially in the light path between the two mirrors. Interference fringes consisting of two sets in each field image result, slightly overlapping at the center of the field, with one set being the complement in intensity of the other. The presence of the two sets of fringes limits the useful field in this particular apparatus to approximately $\frac{1}{3}$ the area of the 18-in. diameter schlieren mirrors employed.

A Mach-Zehnder interferometer, modified for photoelastic purposes, has been investigated theoretically by Saenz[129] of the Naval Research Laboratory for use in the analysis of residual stresses in quenched glass objects, which are so highly quenched that their explosive characteristics would prevent the use of cutting techniques for the measurement of these stresses. Promise is indicated in the adaptation of this technique to the study of transient thermal stresses in cylinders, particularly when the temperature differences are so large that thermal and elastic constants of the material vary considerably and the radiation at the surface does not follow the simple Newton Law of cooling, so that the Stefan-Boltzmann Law must be employed. Present photoelastic techniques do not permit ready determination of such thermal stresses.

The interferometer has been used at the Ballistic Research Laboratories at Aberdeen[130] in the study of approximately axisymmetric flow at various Mach numbers about a cone-cylinder in free flight. Plotted fringe shift data from the region near the nose of the cylinder fall into a narrow band indicating approximate conicity. They also check closely the corresponding theoretical fringe shift data calculated for Taylor-Maccoll flow.

K. Medical

In the medical field, a rather large number of medical still cameras have appeared on the market, all essentially using the same embodiment: namely, a single-lens reflex 35-mm camera together with two light sources close to the lens, all held on a common base.[131] Modifications of this lighting system have been developed, using a circular electronic flash tube disposed annularly about the lens.

In June of 1950, Neyhart[132] described an advance over previous systems for body-cavity motion picture photography utilizing a coaxial light source and taking-lens system. This camera is a combination of a 16-mm magazine-loading electric camera and a projection-type light source and optical system. The unit provides a beam of collimated light which is coincident with the camera lens cone, the two cones being identical in space. Thus, the field area illuminated by the beam is identical with the area photographed by the camera and varies in width from $1\frac{1}{2}$ in. to $4\frac{1}{2}$ in. at camera distances of from 10 in. to 30 in., respectively. In this system, light from a 1000-w lamp is collimated through a condenser and projection lens and passes through a special transmission-reflection mirror. This mirror consists of alternate clear and silvered bands which accomplishes both the passing of half the light and reflection of the subject, using a

mirror and taking-lens system, to the film. The projection and taking lenses are mechanically coupled and the camera permits viewing of the subject continuously during photography by both camera operator and surgeon. It has been applied to shadowless photography of natural body cavities, and cavities resulting from surgery, which can be visually examined without the aid of optical instruments.

The Bausch & Lomb Optical Company introduced its new retinal camera during 1950, employing fundamentally the principles of the Zeiss-Nordensen retinal camera.

A semiautomatic camera for still photography of surgical procedures was developed at the Mayo Clinic.[133] This camera, utilizing flash lamps dispersed about the lens, is housed in a sterilizable blimp.

An accessory for medical photography, the Kamm Stand, was described by Hansell.[134] This camera stand provides a rigid support for a camera to be placed at any point within a sphere of a 4-ft radius. It will also support the weight of at least one camera operator in several positions.

A most interesting paper appeared in the *British Journal of Photography*[135] concerning the application of photogrammetric techniques to medical research. The use of automatic plotting apparatus and stereogram pairs taken on fine-grain film has produced particularly accurate physical measurements of surface areas and of individual cells. It was stated that the location of a point can be determined with a mean error of ± 0.005 mm or $\pm 0.03\%$ of the camera-to-object distance.

Infrared photography has been applied to clinical investigations in the medical field[136] where it is possible to show comparatively superficial vascular changes, mainly in the subcutaneous veins. Applications have been made in anatomical, physiological, pathological and clinical fields.

L. Microscopy

Microscopy in its various stages will be dealt with very briefly. A large number of papers have appeared in 1950 in this field, and a few are listed in the bibliography of this section.

Recent developments in light microscope instruments were discussed by Foster of Bausch & Lomb.[137] New objectives for ultraviolet microscopy and phase-contrast microscopy were described. Silge and Kuhn of San Francisco brought out their Orthophot,[138] a relatively inexpensive photomicrographic apparatus, and the American Optical Company announced their new inverted metallograph.[139]

Resolution of microscopic systems has been more thoroughly investigated[140] and it was found that the resolving power of the microscope is underestimated by the classical theory.

The use of a Western Union point source for photomicrography was disclosed by Weber in the *Journal of the Biological Photographic Association*.[141]

The applications of photomicrography were many as reported in the literature of 1950, and included technique information in such fields as metallurgy,[142] dental microscopy,[143] and in the study of the crazing of polystyrene specimens.[144] (This latter study utilized the light microscope, the electron microscope, and the X-ray spectrometer.) Photomicrographic techniques were used to study the solidification of small metallic droplets at the General Electric Research Laboratory.[145] A special high-low temperature microscope stage was developed in order to study specimens from the temperature of liquid nitrogen to an upper temperature determined by the melting point of the specimen.[146] Surface tension effects in thin silver films were studied, using both bright field and polarized light microscopy and electron microscopy.[147]

Phase microscopy came in for further investigation during 1950, and a number of papers appeared in the *PSA Journal*,[148]

Journal of the Optical Society of America,[149,150] and the *Comptes Rendus* of the Academy of Science, Paris, France.[151,152] The *PSA Journal* article by Richards[148] disclosed the use of an FT-230 gaseous-discharge tube used for phase photomicrography, including time-lapse motion picture techniques. Benford and Seidenberg[149] of Bausch & Lomb described the application of phase-contrast microscopy related to opaque specimens, while Saylor, Brice and Zernike[150] discussed the requirements and applications of color phase-contrast microscopy. This latter technique permits clear distinction between effects caused by scattering or general absorption and those caused by small differences in refractive index or thickness. The *Comptes Rendus* papers disclose an apparatus taking the place of the eyepiece to give images in variable phase contrast,[152] and a second apparatus, which is independent of the microscope, utilizing a phase plate of variable absorption.[151]

A wide interest in ultraviolet microscopy is evidenced by the literature. Grey of Polaroid described newly developed objectives of catadioptric type of intermediate numerical aperture.[153] The color translation microscope of E. H. Land, previously disclosed in 1949, was the subject of a brief review by W. F. Berg.[154] R. C. Mellors,[155] working at the Sloan-Kettering Institute for Cancer Research, gave a rather extended paper on the reflecting microscope used for qualitative and quantitative ultraviolet microscopy. An apparatus employing visible phase focusing and allowing a series of photographs in the ultraviolet range together with step-wedge calibrations to be rapidly taken, was designed for the ultraviolet photomicrography of living cells.[156] Tumor tissues were also studied in visible light by means of a phase contrast searcher and photographed at 2570A using a quartz monochromat.[157] Jones of Kodak Ltd.[158] described techniques employed in the ultraviolet photography of hot metal surfaces.

Considerable progress was reported in electron microscopy during 1950 with the introduction of the Philips 100-kv electron microscope,[159] the RCA 50-kv table model,[160,161] the 100-kv three-stage electron microscope built by Metropolitan Vickers of England,[162] and the field electron microscope of Muller of Germany.[163] The light microscope and the electron microscope were compared by Marton[164] of the Bureau of Standards, and modifications, techniques and applications were discussed in many other papers.[165–180]

The X-ray microscope was also under further investigation during 1950 and some progress has been reported.[181–184]

An exposure meter for photomicrography was reported in *Electronics* in January 1950.[185]

A two-wavelength microscope has been devised[186] in which light of one wavelength is permitted to flow as far as the diffraction image of the object. The light of a second wavelength is substituted to this plane, and continues to flow through the rest of the optical system. In this case, the magnification depends not only on the image-to-object distance ratio, but also the ratio of the wavelengths used. Using X-rays and visible light, the magnification is of the order of 3×10^5. Studies of the structure of marcasite were made.[187]

An observation chamber for ultramicroscopic investigations on aerosols was reported,[188] and techniques of microspectroscopy,[189] and infrared microspectroscopy[190] were described.

M. Radiographic

A review of recent developments in medical photography and radiography was made by Watson[191] of England. A number of new X-ray devices were disclosed during 1950 including a 70-mm fluorographic camera[192] employing a curved mirror and correcting lens of the Schmidt type, having an effective aperture of $f/0.75$. This camera is made by De Oude Delft in Holland. The film is held in a curved pressure plate, and a

resolving power of 30 lines/mm at the center and 25 lines/mm near the edge is claimed. The trend in fluorographic recording, the indirect X-ray recording method, has been toward Schmidt optics of high aperture.[193] Fairchild, in this country, has disclosed such a camera.

One of the important problems under investigation is the amplification and intensification of the X-ray image. Further work during 1950 indicates strides toward this realization. The use of the image-converter tube for fluorescent image intensification was described by Rawlins[194] and was shown to produce an intensification of some five-hundredfold at the most, bringing fluoroscopic observations to a brightness of about 0.1 mL (millilambert). Moon,[195] in this country, described the use of a scanning X-ray tube to accomplish the same end.

Several general papers on the subject of the generation, of properties of X-rays, and their application were presented by Tasker,[196, 197] and by Meakin[198] (on the subject of megavolt radiography).

X-ray photographs of the vocal tract[199] were used to determine the dimensions for each vowel permitting calculation of resonances in the study of normal speech. From these data, an electrical circuit has been made to produce acceptable vowel sounds.

Cineradiographic devices were described by Campbell,[200] L. Reynolds, et al,[201] R. J. Reynolds,[202] Janker,[203] and in *Engineer*.[204] Essentially, all these workers are utilizing the indirect method in the studies of medical subjects to frame frequencies of the order of 50 frame/sec. In most cases, a high aperture lens of the order of $f/1.0$ or faster, is employed.

Such a device is also described in *Electronic Engineering*[205] built by Watson and Sons in England. This device uses a 120-kv, 400-ma X-ray tube and a 35-mm motion picture camera fitted with a 4-cm $f/1.5$ lens, photographing the fluorescent screen image. The X-ray tube is excited only during the camera shutter-opening. Variable frame frequencies from 3.125 to 50/sec have been obtained.

A 120-pulse X-ray tube is synchronized with a motion picture camera in a device for cine fluorography for clinical use, recently described.[206] In this system, after an exposure to 4 pulses of X-ray, the current is shut off for the next 4 pulses while the film is being advanced. For circulatory studies, 15 frame/sec is used, and 30 and 60 frame/sec have been achieved, again using the indirect method.

An electronically controlled cineradiographic device described by Quittner[207] permits pulsing of the X-ray tube for exposures of 3/sec upward.

High-speed flash radiography providing exposure durations of 1 μsec or less were described by Pollitt[208] in England, and Clark[209] in the United States. Exposure durations as small as 0.1 μsec have been produced and applied in the study of explosive phenomena, projectiles in flight, and similar high-speed phenomena. Impulse X-ray tubes providing microsecond pulses were described by Funfer.[210] A million-volt resonant cavity X-ray tube was described by Mills[211] for use as a radiographic stroboscope for the study of objects in movement.

X-ray flash photographs of explosions in water at exposure durations of 2 to 3×10^{-7} seconds were employed by Schall.[212] Shock-wave velocities up to 6600 m/sec and impulsive pressures up to 190,000 atm are obtained in water by means of an explosive charge The velocity of an advancing shock wave is a function of position and density variations measured from the X-ray photographs, permitting pressure-density relations for high pressures to be calculated.

The use of radioactive isotopes in industrial radiography has been given considerable impetus and was reported upon by Tenney[213] of Los Alamos. Image formation by means of X-rays was further investigated by Cauchois,[214] and a method permitting chemical analysis by means of X-rays was reported upon by

Alvarez.[215] In this latter method, the concentration of an element in the anticathode of an X-ray tube is directly proportional to the photographic density produced by the characteristic X radiation of this element. Two photographs are taken, one recording the density of the unknown quantity of the element and the second photograph showing the density for a known quantity of the same element.

An X-ray tube producing a convergent beam of X-radiation in the form of a hollow cone was developed at Syracuse University.[216] The light energy and spectral distribution of four different types of X-ray fluorescent screens were investigated,[217] and the quantum efficiency in photographic X-ray exposures was further investigated by Bromley and Herz.[218]

N. Underwater

Several underwater cameras were disclosed during 1950. Chesterman[219] described a motion picture camera having a 100-ft film capacity enclosed in a watertight casing with a self-contained electric drive. Focusing and stop controls were brought to the outside. The camera was slightly positively buoyant and could be operated by a diver with air-breathing equipment to permit work down to a 45-m depth.

Bucher[220] employed a Rolliflex in a suitable housing for still photography to 20 m in depth and describes color work when very high intensity conditions obtained at $f/4.5$ and 1/50 sec. Jenner[221] described a still camera fitted with a battery-capacitor flashlamp illumination system containing six flashlamps to provide for color photography in as short an elapsed time as 3 sec. The apparatus is contained in a transparent plastic cylinder.

Underwater black-and-white and color photography was accomplished[222] in Germany using a Robot Camera synchronized with gaseous-discharge tubes which could be discharged at intervals of 8 sec. Hahn of the Woods Hole Oceanographic Institution[223] discussed some of the aspects of underwater photography at great depths. Various cameras were used including the Robot, reflex cameras, and 16-mm and 35-mm motion picture cameras. Illumination was provided by flashbulbs or gaseous-discharge tubes. Interesting sea life and geological studies have been made.

Collins of the Royal Naval Scientific Service[224] describes much of the work that has been accomplished to date by the British Admiralty and in liaison with the French Navy. The spectral transparency of different waters was investigated and photometric studies were carried out. Sunlight and artificial illumination provided by various sources, including 250- and 400-w mercury arcs and 45-w sodium-vapor lamps, were used and 35-mm still and 16- and 35-mm motion picture cameras and shallow-water diving apparatus were employed.

Conger, of the U. S. Naval Photographic Center[225] described, before this Society, the new Aquaflex 35-mm underwater motion picture camera designed and built by Eclair of France. This device permits photography from 8 to 40 frame/sec and has a capacity of 400 ft of film. The Aquaflex is housed in a specially designed container having a supply-demand type compressed-air valve regulated to provide 3 lb/sq in. over sea pressure at the depth of the camera. The air supply is carried in a charged cylinder under the container. A reflex viewfinder permits viewing during exposure and controls are available external to the case.

O. Photosensitive Materials and Treatment

A new film base was developed by Armour Research Foundation[226] for the U.S. Army Signal Corps. The material used is *n*-propyl cellulose, which was stated to work successfully in laboratory tests for wear at temperatures ranging from $-65°$ to $+140$ F.

Speed, contrast, and graininess in the ultraviolet region of 2650 A, were measured by R. D. B. Fraser in England,[227] for 10 motion picture emulsions. The number of photographs which may be obtained for a given radiation dosage is an important characteristic of an emulsion in the ultraviolet cinephotomicrography of living cells. Fraser derived an index useful as a guide to this quantity.

Ultraviolet photographic plates introduced in 1949 and described in 1950 by Schoen and Hodge[228] are made to be sensitive to the very short ultraviolet wavelengths which can only be photographed in the vacuum spectrograph. The plates depend on having the minimum amount of gelatin covering the silver halide of the emulsion to reduce ultraviolet absorption by gelatin to a minimum.

Polaroid-Land film, Type 41, producing black-and-white prints was introduced.[229]

Two new nuclear emulsions were developed by Eastman Kodak, the Type NTB2 and the Type NTC3 plates.[230] The latter is designed to record low-energy alpha particles and low-energy protons to 7 mev.

Kodak autoradiographic plates, Type A and Type No Screen, for use in radioactive isotope research, were also made available.

In addition, a high resolution emulsion for autoradiography was described by Berriman, Herz and Stevens.[231] This material consists of a glass support carrying a strippable 10-μ gelatin layer which carries on its upper surface a 4-μ thickness of fine-grain concentrated emulsion. The characteristics of this emulsion have been investigated and the resolving power measured by making autoradiographs from radioactive test charts producing a value of at least 200 lines/mm. A method of preparing an emulsion for the recording of nuclear particles is described by Demers.[232] It is stated that this emulsion is sufficiently sensitive to record electron tracks at energies down to 1.8 times the minimum ionization energy.

The spectral sensitivity of Kodak No Screen and Kodak Industrial Type K, X-ray films were determined[233] in the region between 0.2 and 2.5 A.

Latensification with ozone, producing speed increases from 9 to 100%,[234] gold sensitization of X-ray films,[235] and a brief review of treatment of under-exposed negatives[236] were described in other papers presented in 1950. The combined effect on the latent image of infrared radiation and intensification was investigated by the Eastman Kodak Research Laboratories.[237]

The use of 6-nitrobenzimidazole and benzatriazole as antifoggants is discussed by Schantz,[238] while ion-exchange methods used for the reclamation of wash water were described by Levinos[239] of Signal Corps Engineering Laboratory.

Double development of nuclear emulsions has been investigated by Jech.[240] Uniform development throughout the depth of nuclear emulsions has been difficult to achieve. Stevens[241] of Kodak Ltd. has investigated temperature coefficients of swelling and development in 100-μ NT1 nuclear plates.

Low-intensity reciprocity failure investigations continued, with papers by Katz,[242,243] and Webb.[244,245] Milne of the Institute of Optics, University of Rochester,[246] studied a new reciprocity failure in exposure at high intensity and short duration. For simple blue-sensitive emulsions, the reciprocity law is found to be valid for exposure times somewhat shorter than 10^{-5} sec. However, in the case of Super XX (dye-sensitized emulsions), a new reciprocity failure is observed for exposure times shorter than 10^{-6} sec and amounting to 0.2 to 0.3 log units of exposure referred to a density of 1.0, for exposure times of 10^{-6} sec. Exposures made with the aid of filters indicate that this failure occurs only for that part of the exposure contributed by the sensitizing dyes and does not occur for

exposure to blue light absorbed directly by the silver halide.

P. Special Photosensitive Systems

The metal diazonium process was further described by the Philips Research Laboratories.[247,248] This system of photographic reproduction has particularly high resolving power (of the order of 1200 lines/mm). Cellophane may be used for the film base, and the system applied to such applications as sound-on-film recording, microfilming, and other processes where a high resolution is of importance. It is understood that the Philips Research Laboratories have discontinued their technical development of this system. This system offers interesting possibilities and we hope that means may be found to continue investigation.

Xerography, previously disclosed, was the subject of a brief review paper in 1950.[249] Continued development of the process has led to its application in radiography.[250] In Xeroradiography, a metal or transparent support is coated with a semiconductor sensitive to X-rays, which is sensitized by charging it. This surface charge is discharged into the conductive backing in areas exposed to X-rays. The resultant latent electrical image is developed in a few seconds by flowing a resin powder over it which clings to the still-charged regions. Paper prints may be made by transfer of resin. It is claimed that the speed of Xeroradiography exceeds that of most nonscreen X-ray emulsions, that the contrast sensitivity is better than the 2% required for aircraft inspection, and that the resolution exceeds 200 lines/in.

Kaprelian[251] of the Signal Corps Engineering Laboratory presented an extensive survey of photographic processes and materials and of unconventional processing systems.

Q. High-Speed Processing

Much attention has been given to the development of apparatus and techniques for rapid processing of emulsions.

A self-processing camera was described by Jackson[252] intended to give developed photographs of shell bursts or PPI cathode-ray pictures on 35-mm film within 15 sec after exposure. The film is exposed and then passed through a thermostatically heated developing tank, and thence to an illuminated viewing position after excess solution has been removed by passage through a light-tight roller squeegee. The film must be lowered into the developer simultaneously with the start of the film through the camera, and must be lifted out just before the film comes to rest to prevent melting the emulsion. The developer is used at 100 F, and consists of Johnson's M.Q. undiluted, and contains 6%–7% of caustic soda. Fixing is accomplished with an acid potassium iodide bath. The image thus consists of black-developed silver against a yellow background of silver iodide and is stable to further light action.

Levinson[253] of Kodak Ltd., described the development of a small continuous processing machine for the development of paper or film of 35-mm width or less, which has no sprockets, and is not restricted to one width of film at a time. This device is of flexible construction permitting rapid modification to suit particular needs. Provision is made for eleven tanks, 4 in. square of 11-, 6-, or 3½-l capacity, which have three hose connections to allow variation in agitation and circulation. Speeds from 3 in. to 15 ft/min are obtainable.

Levinson[254] also discloses a compact device for the rapid processing of 35-mm paper in roll form. The unexposed paper is passed into a small tank containing a developer and thence over a large heated drum to a take-up reel. The exposure is made after the paper passes through the developer and immediately upon contact with the drum. A paper speed of 25-mm/sec and a developer temperature of 43 C are used. The trace is visible in half a second at 12½ mm from the point of exposure.

Sixteen-mm motion picture film may be processed in a new rapid film processor developed at the General Precision Laboratory in Pleasantville, N.Y.[255] A hardened emulsion (Eastman Fine Grain Release Positive Film, Type 7302) is processed at elevated temperatures of the order of 120 F; a total processing time of 40 sec between input and output ends of the processor obtains. The linear speed of travel of the film through this processor is 36 ft/min, corresponding to 24 frame/sec. The device has been used in the intermediate-film theater television system.

Ives and Kunz of Eastman Kodak[256] described recent work on rapid processing methods, and indicated that the times of treatment can be reduced by a factor of 25 to 50.

Leonhard Katz of the Raytheon Manufacturing Co. has disclosed the use of high-speed turbulent film drying and processing based upon his theoretical and practical research in molecular diffusion processes.

Tuttle and Brown of the Kenyon Instrument Co.[257] have developed a high-speed processing system utilizing vacuum injection of the processing fluids. In the embodiment they disclose, a 35-mm motion picture film carried in roll form is exposed through a self-contained lens, successively stepped to three vacuum-injected processing fluid stations, and thence to a dryer and projection system. The total time elapsed between start of development and projection may be of the order of 4 sec.

Stabilization processing to produce images of moderate stability without washing was reported on by Russell, Yackel and Bruce.[258]

The Engineering Division, Photographic Laboratory, of the Air Materiel Command reported a new Ansco Color Film processing method in which the processing time of 90 min originally taken was reduced to 20 min. A prehardened emulsion permits 80 F processing.

A relatively rapid film drying process applied to X-ray sheet film was described by Davies and Soper.[259] A 25% solution of diacetone acohol in petroleum ether is used, the film immersed after washing and blotting and withdrawn 1 min later. The water is effectively removed from the swollen gelatin layer and wiping with a soft cloth readies the film for projection and handling.

R. Optical Elements

In 1950, a number of interesting objectives were developed. A relatively simple variable focus lens was described by Cuvillier,[260] the Berthiot Pan-Cinor. This lens provides for a transmission of 85% and focal lengths of 0.8 to 2.4 times the focal length of the associated objective lens. For example, a Pan-Cinor lens for 16-mm film of nominal focal length of 25 mm, provides focal lengths of 20 to 60 mm. The aperture of this lens is $f/2.8$. Wide-angle and telephoto types have been developed.

A wide-angle underwater lens was developed by Thorndike,[261] covering a half field of $37\frac{1}{2}°$. The area imaged with this lens is more than seven times that covered with the customary arrangement of a conventional camera lens behind a plane window.

Considerable further development of Schmidt objectives was disclosed in 1950. Wormser[262] described the design of a wide-angle (40°) Schmidt system having a focal ratio of $f/0.7$. Seegert[263] reviewed progress in the development of wide-aperture photographic objectives and Paul[264] reviewed current designs of catadioptric objectives. A refractive lens of aperture $f/1.0$ has been described,[265] the Tachonar, and is available in focal lengths of 25, 50, and 75 mm.

Interference filters permitting the transmission of narrow-wavelength bands or for the exclusion of infrared, have been introduced by Fish-Schurmann, Bausch & Lomb, and Baird Associates, and have been described by Greenland and Billington[266] of England, and Roig and Des-

camps[267] of France. An interference mirror used in an arc projector to transmit infrared and reflect the visible spectrum was described by Koch.[268]

The use of the electrooptical shutter has been applied by Babits and Hicks of Rensselaer,[269] using ADP crystals, for the production of electrically controlled color filters.

S. Light Sources

A number of interesting light sources and their applications were described in 1950. A high-intensity spark source, providing an effective duration of the order of 10^{-7} sec has been developed at Catholic University.[270] The system used permits a much more intense source than has been previously developed.

The light emission from high-current spark discharges of the flash-tube type, has been studied by Glaser.[271,272] Sparks obtained with the discharge of the large capacitances (0.01 to 5 mf at 2 to 15 kv) through gases at 1 to 17 atm were studied for spectral emission. Additionally, oscillator discharges were studied. The FT-110 flash tube providing for high efficiency at low voltage was described by Noel and Davis.[273] Barstow[95] applied a very small quartz tube designed specifically for an infrared instrument recorder. The use of the gaseous-discharge tube as a light source for motion pictures was analyzed by Carlson and Edgerton,[274] while Olsen and Huxford[275] of Northwestern University measured the electrical and radiation characteristics of flash discharges in quartz tubes filled with rare gases at pressures of about 100 mm of mercury.

Laporte has applied xenon flash tubes to photomicrography at repetition rates up to 25/sec,[276] and has investigated[277] the use of the gaseous-discharge tube for projection at 24 frame/sec, a flash tube operating at 48 flashes/sec has been employed. An embodiment of this nature was described in a German journal by Hagemann[278] in a continuously moving film projector.

A compact source lamp described by Bourne and Beeson[279] has been employed for high-speed motion picture photography. This device, named the Cine Flash, permits the flashing of two compact source mercury-cadmium lamps operated in series at their normal wattages of 1 kw as continuous sources, and then flashed at 3, 5 or 10 kw for 5, 2 or 1 sec. This light output is sufficient for color photography at speeds up to 3000 frame/sec or for black-and-white photography with small lens apertures to give considerable depth of focus.

General Electric introduced a schlieren light source utilizing their H-6 mercury lamp.[280]

Hoyt and McCormick[281] have made an intensive study of the dependence of peak intensity and duration of the visible light from arcs of a few microseconds' duration in xenon, krypton and argon on the input energy, the circuit characteristics, the gas and the pressure. The ultraviolet radiation of the high-pressure xenon arc was investigated by Baum and Dunkelman.[282] This source, operating under a pressure of approximately 20 atm, provides a particularly intense ultraviolet source. It was found that the radiance of the central spot exceeds that of the carbon crater by a factor of 23 at 2500 A, 12 at 3000 A, and 6 at 3500 A.

Carbon arcs have been the subject of further research, and have led to the development of a new high-intensity carbon arc lamp described by Gretener.[283] This device, called the Ventarc, produces an extremely high brilliance.

A power supply for the Western Union concentrated arc lamp was described by Mitchell,[284] and Buckingham[285] disclosed the new Western Union open-air concentrated arc lamp. This latter device, using molten zirconium, provides an intense light source of small size, relatively long life, and good stability.

T. Nuclear

With the advent of the new nuclear emulsions produced by Kodak here and

abroad, by Ilford in England and of special emulsions produced by individual investigators, considerable use is being made of photographic techniques in nuclear research. Much of the literature deals with the application of these techniques in such fields as cosmic ray, particle disintegration, particle energy and similar studies. Refinements in autoradiographic techniques have been reported and applications appear to be quite widespread. Work is continuing on the refinement of cloud chambers with a continuously sensitive cloud chamber being reported.[286] Characteristics of nuclear photographic emulsions, the techniques in which they are used, and the means for studying the results were subjects for a number of papers. (See Section **O** above.)

One unusual application concerned itself with the study of bird flight.[287] An apparatus measuring 8 mm by 5 mm, is attached to a bird. The device consists of a tube containing an annulus with a source of alpha particles at one end, a piece of photographic emulsion at the other, and a steel ball between. This device is established in such a manner that when the bird is in flight, there is a clear passage between the alpha-particle source and the emulsion, and when not in flight, the path of the alpha particles is blocked by the ball. Data on flying time may be deduced from photometric measurements of the emulsion.

U. Miscellaneous

A new apparatus permitting simultaneous and instantaneous photography of a 360° panorama was described by Blet[288] in France. Two silvered cones are oriented axially with the apexes facing. The image is reflected by the upper cone to the second cone and thence to a strip of 35-mm film held in a glass cylinder arranged about the second cone. In the image produced, the ordinates are amplified relative to the abscissas which proves advantageous in applications for which the device was designed, such as the measurement of sunlight variations with hour of day and season.

A device for automatic exposure control designed for the U.S. Air Force was disclosed by Bruck, Higgins and Ward[289] of Specialties, Inc. The control system consists of an additional lens and a photocell whose output is amplified to drive a servomotor geared to the camera-lens aperture. The device has a rapid response and is said to be particularly useful for aerial photography.

Photographic methods for production of optical gratings and reticles have been proven of considerable use. Two good survey papers were presented in 1950 by Leistner[290] and by Gundlach and Rzymkowski.[291]

The Ansco-Sweet-MacBeth color densitometer introduced earlier was described in this Society's JOURNAL by its designer,[292] while Morrison and Hoadley[293] of the Kodak Research Laboratory disclosed their spectrosensitometer. This latter device is designed to expose photographic materials through the range of 3500 and 9500 A for the evaluation of spectral sensitometry. The sensitometric steps are produced with repetitive increments of radiation level of log 0.3.

A qualitative technique for rendering lines of magnetic force visible was introduced.[294] The pole pieces of a magnet are covered with a suitable insulating material containing a few holes or slits. They are connected to each other by a tube containing an anode and cathode necessary for electrical gas discharge, which, under suitable pressures, becomes visible along the lines of force originating from the uncovered points on the surfaces of the pole pieces.

Another qualitative technique, this one making ultrasonic waves optically visible, was devised in Germany by Schreiber and Degner.[295] A ZnS–CdS phosphor is used of unknown phosphor content. After exposure to light for intervals between 30 sec and 5 min, the resulting phosphorescence is extinguished at the areas of maximum absorption of ultra-

sonic energy. Using a quartz transmitter of 1.56 mc/sec, satisfactory photographs were obtained at quartz-to-phosphor distances of 0.4 to 11 cm. Similar work was reported by Eckardt and Lindig,[296] also of Germany. They used a vessel containing air-free water closed by a celluloid film covered with a phosphor on its upper surface and placed 6 to 12 cm below a quartz transmitter operating at 70 w and 1.42 mc/sec. The phosphor is first illuminated by an arc lamp fitted with a quartz condenser for about 1 min. About ½ min after the illumination is turned off, the quartz ultrasonic transmitter is energized, and the phosphor glows producing a sound picture which is photographed. When the transmitter is shut off, a negative sound picture is produced. Those parts of the phosphor which glowed previously, now appear as dark zones.

Phosphors are used for temperature field measurements in a method developed by Urbach and others at the Eastman Kodak Laboratories, Rochester, and described previous to 1950. Temperature-sensitive phosphors reveal as dark areas localized small increases in temperature when the phosphors are illuminated by ultraviolet light. Two techniques may be employed: one in which the phosphor is in contact with the body under study, and the second in which an image of the body is formed on a thin sheet of phosphor by reflection of the heat radiation from the body. It is said that accurate temperature distribution maps may be produced by photographic photometry from photographs produced in this manner. A review paper on the subject was presented by Urbach.[297]

An interesting apparatus permitting time-resolved spectroscopy of single sparks and other short-duration light sources was described by Gordon and Cady.[298] A Bausch & Lomb Medium Quartz Spectrograph was modified to permit sweeping the image of a selected region of the light source along the length of the slit by means of a rotating mirror operated at speeds to 36,000 rpm. The time base may be made as short as 10 μsec and time resolution of events in the source as brief as 0.5 μsec. Exploding wire and spark spectra were studied by this method.

V. New Publications

A number of new or reconstituted publications of interest to photographic instrumentation appeared in 1950. *Photographic Science and Technique*, a quarterly technical supplement designated as *Section B* of the *Photographic Society of America Journal; Photographic Engineering*, another quarterly, the official journal of the Society of Photographic Engineers of Washington, D.C.; *Functional Photography*, a monthly publication originating in England; and *Photo-France*, a monthly journal of general photographic interest.

The German journal *Photo-Kino-Technik* has changed its name to *Photo-Technik und Wirtschaft*.

V. CONCLUSIONS

From the foregoing brief abstracting of the literature of interest to photographic instrumentation, it may be concluded that this information is appearing in an ever-increasing number of journals and that it is becoming more difficult to locate and utilize.

A considerable effort is being made in a number of fields, and the design, development and use of photographic instruments and techniques are expanding. High-speed still and motion picture photography, oscillography, data-recording photography, reduction of data instrumentation, schlieren techniques, high speed processing, microscopy, radiography and nuclear photographic techniques are being given considerable attention and much more work for the future is indicated.

Widespread dissemination of information in this field is not currently possible. Very often, the editors of the several technical journals, because of its highly specialized nature, must omit photographic instrumentation data. Rarely will applications papers devote any space to a discussion of the instrumentation involved. No continuing digesting (as contrasted with abstracting) is being done in English, and the French publication, *Science et Industries Photographiques*, which comes closest to what is needed, is limited in accessibility to workers in this country. This publication is concerned in large measure with a number of photographic fields other than photographic instrumentation — particularly chemistry and physics relating to photosensitive systems. Although a remarkable scope is covered, it being essentially the work of one man, L. P. Clerc, it cannot be exhaustive. M. Clerc has for many years brought forth, almost single-handed, this admirable work and the author hopes that continuing survey with greater emphasis in the field of photographic instrumentation patterned along the line so remarkably developed by M. Clerc, can one day be established in this country.

In addition to the scientific journals of the world, an untapped source of considerable magnitude of data in this field is to be found in the research reports of government agencies and of government-sponsored private research activities. Much important information concerning instrumentation in this and other fields has received only small dissemination because no mechanism has been set up to digest it and because of security restriction, often too stringent. It is hoped that at least the nonclassified information can be included in the digest advocated.

The Society of Motion Picture and Television Engineers, through its liaison with the other technical societies concerned, hopes to improve dissemination of photographic instrumentation information in a number of ways presently under investigation. Steps are being taken to explore the possibility of establishing the continuing survey proposed.

The outlook for photographic instrumentation for the future continues to be bright, with new and large-scale effort being made in many directions. The design and development of new instruments is being accomplished more and more by those skilled in the properties of the photographic medium, rather than by investigators in the several sciences who find photographic techniques of use in their work. This trend will lead to better instruments on the commercial market, and will help to extend the usefulness of these techniques.

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Further Report on Screen Brightness Committee Theater Survey

By W. W. LOZIER, Committee Chairman

THE RESULTS of a survey by the Screen Brightness Committee in 125 indoor theaters and 18 West Coast studio 35-mm review rooms have recently been presented in this JOURNAL.[1] These included data on theater seating capacity, screen width, screen brightness, side and corner distribution and screen reflectivity.

The survey data included measurements of the incident illumination on the theater screen at the center, the two sides and at two diagonally opposite corners.[2] These data make possible an analysis of evenness of balance of illumination on the screen.

Side and Corner Unbalance on Individual Projectors

Figures 1 and 2 show the range of side and corner unbalance observed with the 251 projectors in the indoor theaters and with the 36 projectors in the 18 West Coast review rooms. Side unbalance is defined as the difference between the two side readings of intensity of illumination on the screen divided by their average, expressed as a percentage. The corner unbalance is similarly determined from the two corner readings for each projector. These unbalance values can also be expressed as the ratio of high to low value and this scale is shown at the tops of Figs. 1 and 2. These refer solely to the variations over the screen with individual projectors.

Figure 1 shows that a little less than one-third of the theater projectors had a side unbalance of 10% or less. Another third had 10% to 30% unbalance. About 18% of the projectors had an unbalance greater than 40%, which means one side was 50% or more higher in intensity than the other.

Figure 2 shows an even wider range of corner unbalance. One-quarter of the theater projectors had a 0 to 10% unbalance, over one-third had 10% to 30% unbalance and almost one-fifth were over 40% out of balance. Approximately 5% had over 70% corner unbalance, which means that one corner-intensity value was more than twice that of the other.

The data on the review rooms are in striking contrast to the indoor theaters and show almost two-thirds of the

Presented on October 19, 1951, at the Society's Convention at Hollywood, Calif., by W. W. Lozier, Committee Chairman, Carbon Products Service Dept., National Carbon Company, Division of Union Carbide and Carbon Corp., Fostoria, Ohio.

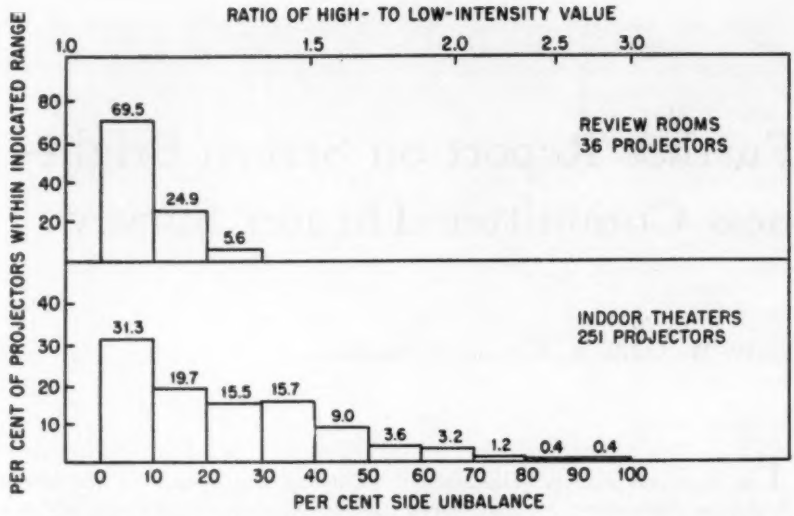

Fig. 1. Unbalance of intensity of illumination at sides of screen. Range obtained in the survey refers to side-to-side difference on the screen with the same projector.

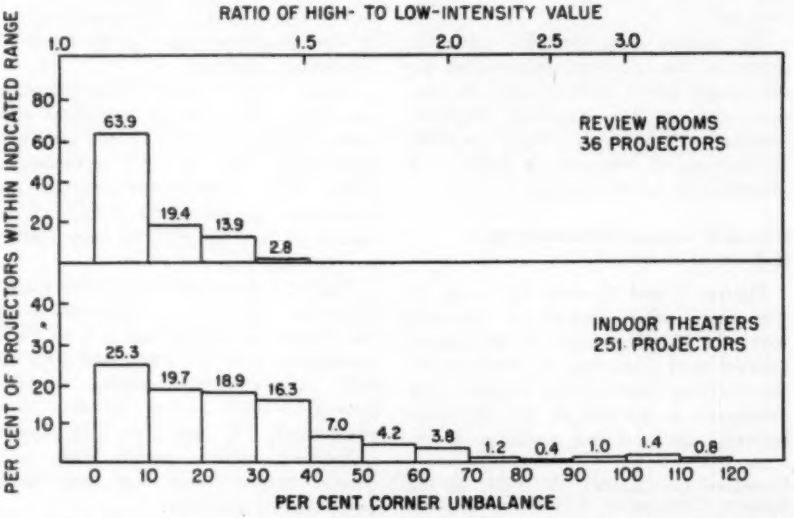

Fig. 2. Unbalance of intensity of illumination at corners of screen. Range obtained in the survey refers to corner-to-corner difference on the screen with the same projector.

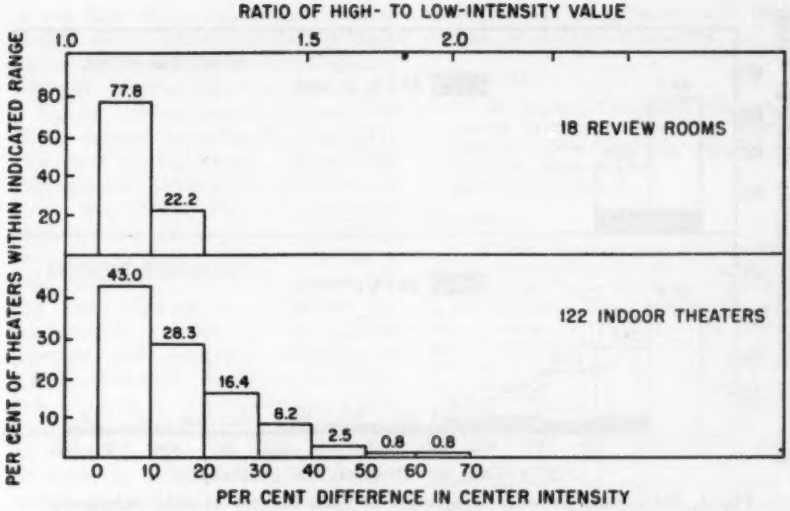

Fig. 3. Difference between projectors in each theater in intensity of illumination at center of screen. Range obtained measures change observable at change-over.

projectors to have less than 10% side and corner unbalance. This better review-room performance will be evident in the further comparisons to be shown.

Comparison Between Projectors in Each Theater

The percentage difference in intensity of illumination at the center of the screen has been determined for the two projectors in each theater. (The maximum difference was used in cases where there were more than two projectors in a single theater.) This, then, is a measure of the change in illumination at the center of the screen at the time of a change-over. The distribution of such center-of-screen differences for 122 indoor theaters is given in Fig. 3.

About 40% of the theaters had a difference of 0 to 10% in center-of-screen intensities for their projectors. A little over one-quarter of the theaters had a change of over 20%. More than three-quarters of the review rooms show less than 10% difference in intensity between projectors at the center of the screen.

In addition to the changes in intensity at the center of the screen, at the time of a change-over, changes in unbalance of illumination on the screen may also be observable. Figures 4 and 5 show how the side and corner unbalance differed between the two (or more) projectors in the 122 theaters. Two factors contribute to a change in unbalance of sides and corners. One of these is the change in magnitude of unbalance in going from one projector to the other, and the other factor is a change in direction of the unbalance. For example, if the side of higher intensity is on one side of the screen with one projector and on the other side of the other screen with the other projector, then this would produce a noticeable shift of unbalance at a change-over even though the magnitude of unbalance were the same in both cases. This was measured by combining the numerical magnitude of unbalance in such cases and these theaters are represented by the shaded portions of Figs. 4 and 5. Approximately one-quarter

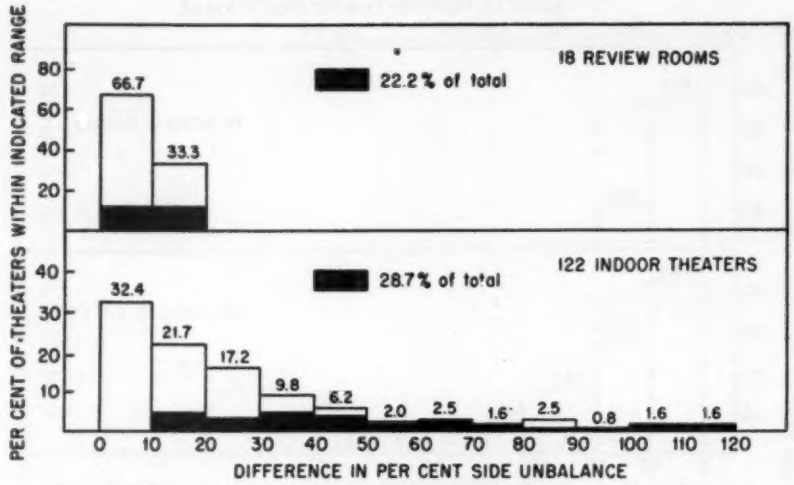

Fig. 4. Difference between projectors in each theater in side unbalance. Range obtained in the survey measures change observable at change-over.

Note: The shaded portion represents those theaters in which the side of higher intensity is oppositely positioned on the screen for the two projectors of the same theater.

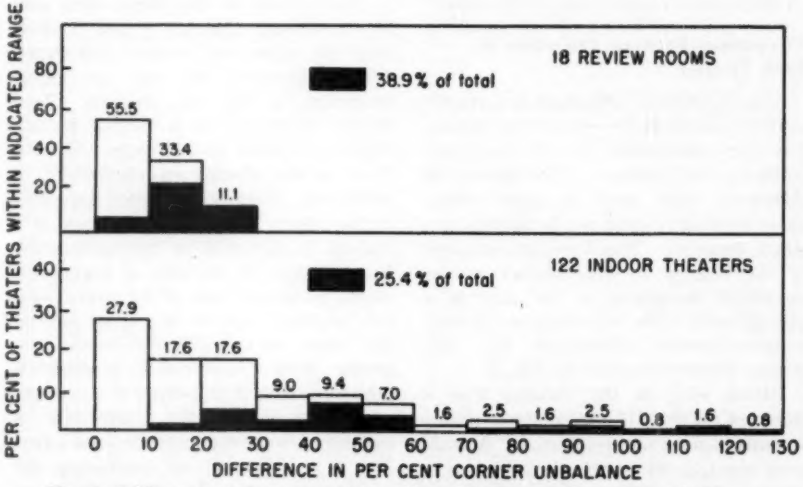

Fig. 5. Difference between projectors in each theater in corner unbalance. Range obtained in the survey measures change observable at change-over.

Note: The shaded portion represents those theaters in which the corner of higher intensity is oppositely positioned on the screen for the two projectors of the same theater.

to one-third of the indoor theaters and review rooms experienced such changes in position of side and corner of highest intensity at the change-over.

Figure 4 shows that about one-third of the theaters experienced a 0 to 10% change in side unbalance. Almost half experienced a change in unbalance of more than 20%. Figure 5 indicates that the change in corner unbalance runs slightly greater than the change in side unbalance. It is to be noted that the large changes in unbalance are contributed primarily by the shaded portions and represent, therefore, a change in position on the screen of the side or corner of higher intensity. The change of unbalance of the review rooms is much less than that of the theaters, as would be expected from the smaller unbalance of the individual review-room projectors as shown in Figs. 1 and 2.

Summary

These data have indicated that many theater screens are illuminated in a noticeably and in some cases objectionably unbalanced manner considering both individual projectors and also change-overs between projectors. The much better balance of the review-room screens is believed to indicate the practicability of theater improvement. Many factors can probably contribute to such improvement, ranging all the way from installation of better designed equipment in some cases to simply better adjustment and operation of existing equipment in other cases.

The Screen Brightness Committee recognizes a primary responsibility in setting up workable recommended practices regarding intensity and distribution of screen illumination which will insure effective projection of motion pictures. However, until these are formulated, many of the undesirable situations can be greatly improved by better attention to the details of operation and maintenance of existing equipment.

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Discussion

E. R. Geib: I believe that this committee should be complimented for the work done so far, as these facts will be very beneficial to the industry. Now, I would like to ask one question. I think he has partially answered it already, and that is I assume that the intention of the committee is to continue the work by establishing a standard of uniformity of light from side-to-center, from corner-to-corner, and also the ratio of the light from side-to-center.

W. W. Lozier: Those are two of our active projects. We haven't anything to report on them yet, but we've given a good deal of time to discussion of them. We feel that the portion dealing with maintaining the screen and balance, that is side-to-side and corner-to-corner, both on the same screen and between projectors, is something for which we can arrive at a workable recommendation fairly quickly. The other, as to just what the distribution should be, whether it should be 80%, 100%, 65% side-to-center, is going to be a more difficult job.

Mr. Geib: Harry Rubin of Paramount Pictures has just suggested that this work be continued because it is going to lead to better projection.

Dr. Lozier: We certainly hope so. We're meeting very good cooperation from various people who are looking forward to appearance of this information in the *Journal*. The material will then be available to the public to use in any way it sees fit.

The Committee W. W. Lozier, *Chairman*

Herbert Barnett
H. J. Benham
F. E. Carlson
M. H. Chamberlin
E. R. Geib
L. T. Goldsmith
L. D. Grignon
A. J. Hatch, Jr.
L. B. Isaac
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F. J. Kolb
W. F. Little
L. J. Patton
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Allen Stimson
C. R. Underhill, Jr.
H. E. White
A. T. Williams
D. L. Williams

70th Semiannual Convention

Close technical ties between movies and TV were a "natural" phenomenon clearly apparent throughout the Society's 70th Semiannual Convention in Hollywood last month. From the luncheon at the Hollywood Roosevelt Hotel on Monday, October 15, to the closing session on Friday evening, 600 engineers who took part repeated over and over the *movies-TV* theme. Not only did registration hit a high mark for West Coast conventions, but also attendance at the luncheon and at the Wednesday banquet far exceeded expectations. Even the heavier-than-usual program of 65 technical papers closely packed into 12 sessions failed to exhaust the energies of technical people who came to hear or be heard.

On the next few pages are luncheon remarks made by our President and skillful master of ceremonies, Peter Mole, and by the guest speakers: Donn Tatum, Director of Television, American Broadcasting Company, Hollywood, and Jerry Wald of Wald-Krasna Productions, Hollywood. All three hit the front pages of all motion picture and television trade papers and a fair share of East and West Coast newspapers the following day.

Get-Together Luncheon Remarks by President Mole

[We convened] our 70th Semiannual Convention with a much rosier picture than prevailed at the time of the New York meeting last spring. Since then a concentrated program of selling entertainment to the public has been under way. The motion picture industry has rediscovered the few million people who are willing to spend money to see good motion picture entertainment, and the actor, writer and director ambassadors of good will are speeding to the four corners of the country to stimulate attendance in the motion picture theaters.

All this is as it should be—a deliberate and successful effort to attract the famous entertainment dollar.

Coast-to-coast television was initiated with the signing of the Japanese Peace Treaty in San Francisco. Theater television is developing by leaps and bounds, stimulated by special showings such as the Robinson-Turpin fight in New York. I believe that movies and television are now finding a common ground for their mutual benefit and will complement each other.

These developments should encourage the members of this organization and their associated companies to continue their scientific research in the belief that the entertainment business will continue to expand and that production will need better tools with which to work.

I remarked at the Spring Convention on the lack of unified effort between the engineer, producer and exhibitor. I see no reason yet to change my views. Nor do I see reason to alter my belief that a successful future for the producer and exhibitor depends upon a close alliance with the engineer.

In the past, the production end of our industry has been the recipient of many technical advances brought about by forward thinking men who had the courage to spend time and money on the development of new ideas. From these engineers who carried on their work outside the field of motion pictures came sound and color. Now, in this time of optimism the producers and exhibitors must take the initiative. They must push vigorously for new technical developments and they must be sympathetic to research work in their planning.

Although sound and color came to the motion picture industry from outside interests, further new developments may not materialize in a finished form unless the industry shows a willingness to share in the program. Equipment manufacturers can no longer be expected to do research and development work on speculation. The exhibitors who plan to use theater television or wide-angle projection must share at least part of the engineering burden. Producers who wish to adopt new sound recording methods or improved color processes, must share in the development as well.

It is our way of business life to risk capital—to produce more business and to secure greater benefits—and we should continue this practice. The time is here to complete the cycle on current developments. The capital has been ventured. It still remains to be recovered through acceptance by the industry of technical developments already being offered by the engineers.

As for the future: We must go forward—focus our attention on other engineering advances not yet introduced. And we must concentrate on things that hold promise of enhancing the entertainment values that are the life blood of our industry.

Excerpts From Address by Don Tatum

"Television broadcasting and motion pictures are not mutually exclusive media of communication and entertainment. They will complement each other, each occupying its own particular and important niche in the lives of the American people. A very substantial part of all the television programming will be produced on motion picture film and the great pool of administrative, creative, artistic and technological talent, as well as the magnificent production facilities of the motion picture industry, will constantly and steadily be more and more devoted to the making of filmed television programs.

"When the current allocation problems have been resolved and television becomes a full-blown national medium as more and more television stations come on the air, the impact of this new medium will work changes in the business and the methods of producing motion pictures for theater exhibition purposes. There will be fewer theaters, film costs will go down and there will be fewer motion pictures made for theater exhibition than has been the norm up to the present time. This means that there will be major motion picture studio capacity available for the making of television films and at lower costs than is presently possible.

"There are many similarities in the methods, techniques and objectives of television broadcast programs and motion picture films, but they are not identical. From the creative standpoint, there are close analogies in the techniques of writing and directing and acting, but writing or directing or acting in a television program is a different thing from performing the same functions in the making of a motion picture. The same is true of the technical end. Lighting a motion picture for theater projection and lighting one primarily for television purposes is different; and the requirements with respect to scenery and sets and the like are different.

"The objectives and the end results are different. Under our free system of broadcasting, the television industry must be supported by advertising revenues. As a result, more and more we shall note that television programming, whether live or on film, will come to reflect the necessity for constructing and tempering the programs so as to best serve the needs and the requirements of advertisers while continuing to serve the public interest and to satisfy the requirements of the television viewing public.

"For the same reasons, the importance in television broadcasting of feature length motion pictures made primarily for theater purposes will constantly diminish. This tendency will inevitably result from the different requirements in the two media with respect to time of the program, costs, production techniques and the difficulty of accomplishing with a feature length motion picture that close relationship between the program content and the advertising objective of a television program no matter what may be its form. For that reason I believe that some of the estimates that have been bandied about of the enormous potential value of motion picture libraries now in the vaults of the major motion picture producing companies will prove to be highly excessive.

"I would like to add my confirmation to the point of view which I know is shared by many of the leaders of the SMPTE: that what we should have is a large scale independent research program in which both our businesses would share and in which we would pool our resources and know-how.

"To those in the television business and to those in the motion picture business who look upon each other with distrust, suspicion and sometimes scorn, I would say forget your differences and accept each other because that is what you are inevitably going to have to do. To those in the motion picture business who say that television is simply an extension of the art of making motion pictures, let me say that you are wrong and that there will be no complete marriage of the two."

Excerpts From Speech by Jerry Wald

"Thirty-five years ago, you engineers joined up with a business which, primitive as it was, entertained an easily satisfied public, and made good money.

"It would have been easy then to say, 'The public likes these cowboy and Indian thrillers, and custard pie tossing orgies, even though they shake like a shimmy dancer. As long as the customers cheer when the cavalry rides to the rescue, and howl when the comic takes a pratt fall, or receives a pie in the face . . . why bother about the shakes and shimmies, the flickers and the frequent blackouts? Let's don't throw a monkey wrench into a machine that turns out dimes and nickels, faulty as it is.'

"Luckily, the inventive mind doesn't work that way. You engineers went to work on the machine, and you've been working on it ever since. As a result, you've got us one that turns out dollars instead of nickels and dimes.

"The creative end of our business . . . I don't like that term because if any people in this business are creators the engineers are . . . but I'll use it for want of a better one . . . has of course advanced with you. Sometimes I feel we've been pulled along. Again, the advances have been made by sheer inspiration, and, again, by careful plodding and intelligent planning."

Mr. Wald went on to discuss the much-discussed health of the motion picture industry and expressed a robust optimism with the reminder that he and his partner Norman Krasna have recently launched a $50,000,000 production schedule at RKO, consisting of 60 motion pictures to be filmed over a five-year period.

"With your continued magnificent technical assistance," he concluded, "we will achieve a future that will, by comparison, make the golden past seem like the dark ages."

Following Jerry Wald's spirited address at the Monday luncheon, our Society's David Sarnoff Gold Medal was presented to the initial recipient, Otto H. Schade, for technical contributions to television. A full story about this portion of the Monday program will appear in the December *Journal* along with a detailed account of several other awards including the Warner and Progress Medals which were presented during the Wednesday evening banquet. A complete and accurate list of all papers presented during the 70th Convention arranged in order of actual presentation and including the names of all authors with company affiliations will be the last item in the December *Journal*.

Technical sessions Monday afternoon and evening at the Hotel and Tuesday evening at CBS' Studio A concentrated heavily on television. High-speed photography papers filled the Tuesday morning and afternoon sessions while on Wednesday a group of "high speeders" were guests of the Naval Ordnance Test Station at Inyokern, Calif. On Friday morning another group participated in a desert photographic experiment where atmospheric conditions were favorable and they could concentrate on certain philosophical rather than technical aspects of rapid motion photography.

The Wednesday morning session at the Hotel was devoted to 16-mm film and its use in television and training. After a 1½-hour warm-up on formal papers there was a most enthusiastic panel discussion of the 16-mm emulsion position question. Difficulties have occurred in

the use of 16-mm prints for television broadcasting because certain methods of film production yield 16-mm release prints with emulsion facing the projection lamp, the nonstandard position. When nonstandard release prints are spliced together with prints having standard emulsion position the broadcasters have picture and sound focusing troubles that are rarely predictable. This problem and what can be done about it were considered verbally and at length. The entire discussion was recorded and has been mimeographed for distribution to all participants for review. It will be printed in full in an early issue of the *Journal*. Echoes from the emulsion-position debate were still reverberating when the laboratory session was called to order Wednesday afternoon.

As in most of the Society's recent Conventions, magnetic recording occupied a fair share of the program. Thursday morning and afternoon were entirely devoted to papers on this subject, supplemented by an unscheduled but well attended forum on proposed standards for 35-mm magnetic-track placement that followed the last morning paper. The discussion ran until after 1:30 p.m., forcing a thirty-minute delay in the start of the afternoon papers. Conflicting recommendations were based upon conflicting performance data. Because eventual American standards for track location will be with us for a long time to come they must have a broad and acceptable basis in experience; therefore the entire discussion will be published in the earliest possible issue of *Journal*.

Several different types of three-color motion picture release print films were described and demonstrated during the session on Thursday evening at the Republic Studios scoring stage. Papers on various aspects of lighting were grouped into the Friday afternoon session at the Hotel. That evening the past caught up with the future at the Paramount Studio Theater where several methods of producing pseudoscopic and stereoscopic motion pictures were described and demonstrated with varying degrees of clarity.

As the final session ground to an official halt, there was unanimous agreement that the papers and the local arrangements committees had *really* put on a show. Everyone was exhausted including the usually indefatigable Bill Kunzmann who was glad to see his 70th Convention in 35 years become one with history

Special credit for a good job well done should go to:

Fred Albin, American Broadcasting Company, Hollywood, Papers Committee Vice-Chairman, and in charge of the Papers program for the 70th Convention;

Charles R. Daily, Paramount Pictures, Hollywood, Chairman of Local Arrangements, who organized the sessions held away from the Hotel including particularly the special facilities for the session on stereo motion pictures;

Ed Templin, Westrex, Hollywood, in charge of public address equipment and discussion recording;

Norwood Simmons, Eastman Kodak, Hollywood, "Secretary-General" who planned and supervised both luncheon and banquet programs;

Harold Desfor, RCA, Camden, and *Walter Simons*, Altec Lansing, Hollywood, proficient purveyors of publicity; and

Clyde Cooley and *Frank Erler* who operated film and slide projectors at times under very difficult conditions.

Ladies from all corners of the United States who attended took full advantage of the well organized program prepared for them by the Ladies Committee under the superior administration of Mrs. Charles R. Daily. There were radio and television shows, a luncheon with a costume show and tour of Universal Studios, a tea at the Beverly Hills Hotel and, of course, the Convention luncheon and banquet. Headquarters for the Ladies Committee remained open all week and became the regular gathering place for the fairer participants.

On Tuesday evening officers and staff members of the Society were dinner guests of the Motion Picture Research Council at Chasen's Restaurant. The men who guide the destinies of both engineering organizations enjoyed not only the drinks and fine meal served with customary movie capital hospitality but also welcomed the opportunity to talk shop informally for a couple of hours with men from different ends of the business, including television.

Engineering Committee Meetings

Six Engineering Committees met during the 70th Convention; three at the Headquarters of the American Society of Cinematographers (High-Speed Photography, Sound, Film Dimensions) and three at the Staff Engineer's suite in the Hollywood Roosevelt Hotel.

High-Speed Photography. This Committee, Chaired by John Waddell, met Monday afternoon with an attendance of four Committee members and 14 guests. The key activities consisted of an outline of future Committee work and an effort to expand the work of the Society to better serve the West Coast high-speed photography members.

Sound. This Committee, Chaired by Lloyd Goldsmith, met Tuesday morning with an attendance of 11 members and 15 guests. A very considerable agenda was thoroughly discussed and concrete action undertaken for the future. Key issues were the questions of edge guiding and magnetic recording standards and test films.

Laboratory Practice. Chaired by John Stott, this Committee met Tuesday afternoon with 10 members and guests attending. Several items of importance were discussed and definitive progress made on proposals for negative cuing for printer light changing and brightness of screens in laboratory review rooms.

Color. This Committee, Chaired by Herman Duerr, met Wednesday morning with a rather small attendance of six members and guests. The small attendance precluded any specific actions, but did permit a general but useful discussion on several of the projects before the Committee.

Screen Brightness. Chaired by Wallace Lozier, the Thursday afternoon meeting of this Committee was attended by 10 members and guests who discussed methods of utilizing the theater survey recently completed. In addition, a first draft of the revision of the screen brightness Standard was agreed upon.

Film Dimensions. This Committee, Chaired by A. C. Robertson (alternate for E. K. Carver), met Friday afternoon with a total attendance of six members and guests. Despite the attendance, there was an excellent discussion on low-shrink film and a first draft of a Standard was agreed upon for circulation to the full Committee.

Board of Governors Meeting

The fourth meeting of the Board of Governors during 1951 was held on Saturday morning, October 13, at the Hollywood Roosevelt Hotel in Hollywood, California. It preceded by two days the opening of the Society's 70th Semiannual Convention also held at the Hollywood Roosevelt, and was remarkably well attended. The meeting ended early in the afternoon. A number of Board members left immediately for a chuck wagon dinner sponsored by the Theater Equipment and Supply Manufacturers Association.

FINANCIAL

R. B. Austrian presented the third quarterly financial statement and in the absence of F. E. Cahill, Jr., Treasurer, also read the treasurer's report. It was noted that test film sales, financial aspects of publications and all other administrative operations were within the limits of the 1951 budget. Loss of members who were delinquent in payment of dues continues to be a serious problem. On September 30 there were 300 delinquent members, each of whom had received two membership dues bills and two written invitations for reinstatement. Although still high, this figure had been reduced from 395, the total of delinquent members on June 30, 1951.

The Board was also advised that while recuperating from a recent operation Pierre Mertz saw in a New York newspaper a list of unclaimed monies in the Chase National Bank. He discovered that the list included a "Society of Motion Picture Engineers, address unknown." Dr. Mertz notified headquarters and Mr. Muskat contacted the bank, arranging to pick up an amount of $101.00 that was found to be an unclaimed foreign bank draft held open by the bank since 1936.

As Chairman of the Sustaining Memberships Committee Mr. Sponable, Past-President, reported that he had recently approved the printing of an illustrated brochure to be sent promptly to all Sustaining members of the Society with an individual letter inviting a nominal increase in Sustaining support. He pointed out that this would be the beginning of the Society's Sustaining campaign for 1952 and would ultimately include invitations to a large number of businesses not now represented. He received the suggestion that the large number of television film producers whose work is guided technically by the Society be invited to support the Society's technical work through the medium of Sustaining memberships.

ENGINEERING

F. T. Bowditch, Engineering Vice-President, invited the Board's attention to the schedule of six engineering committee meetings planned for Convention week. A brief report on these committee meetings appears elsewhere in this issue of the *Journal*. Nearly all of the engineering committees had been busy for the past several months reviewing current American standards preparatory to listing for the International Organization for Standardization the ones most suitable for consideration as future international standards. In this connection he pointed out that there had been little real interest among ASA's Photo Correlating Committee in the field of international motion picture standards and that, consequently, there was little enthusiasm for a projected meeting on this subject in New York during June 1952. Since these were the views generally held by engineers in the eastern part of the United States, Mr. Bowditch reported his plan to sound out a number of West Coast opinions on the merits of international standards for motion pictures and on the projected meeting.

If held, host for the international meeting would be Sectional Committee PH22. It had been this committee's view that the meeting should be called if a satisfactory agenda could be developed by early 1952. In that case ASA would be asked to send out the official call for the meeting early in January so that delegates could make their plans in ample time to attend.

There was also extended discussion of a glossary project that had received some attention over the past ten years but had never been attacked vigorously. Mr. Carlson, a Governor and also Chairman of the Standards Committee of the Society, reported that he had arranged for the engineering committees to revive this job by working on a number of sections which Hank Kogel, Staff Engineer, was, at that moment, organizing.

As a matter of interest it was noted that the proposed FCC theater television hearings were again postponed—from November 26, 1951, to February 25, 1952.

Boyce Nemec, Executive Secretary, reported on a meeting of study group 10 of the International Radio Consultative Committee (CCIR) which he and G. L. Dimmick, Magnetic Recording Subcommittee Chairman, had attended in Washington on September 27. Sound recording characteristics was the subject of the session and the meeting was under the chairmanship of Neal McNaughton of the National Association of Radio and Television Broadcasters. He was appointed Chairman of the study group at the VI Plenary Assembly of the CCIR, which was held in Geneva from June 5 to July 6, 1951.

Purpose of the meeting was the discussion of recording characteristics for disk and magnetic records used in the international exchange of radio program material. The technical aspects of the problem were not considered by the Board, but Mr. Nemec expressed some concern over the sudden interest shown by CCIR, a telecommunications regulatory body in the field of industrial international standards. There was an apparent conflict with similar activities now beginning to move through the ASA–ISO channels and Mr. Bowditch offered to look into the question more thoroughly with the object of forming an official SMPTE policy.

EDITORIAL

J. G. Frayne, Editorial Vice-President, reported that his share of program arrangements for the 70th Convention was already completed and that the success of the Papers Committee had been largely the result of efforts by Fred Albin, West Coast Vice-Chairman, and E. S. Seeley, Chairman of the Papers Committee. Ed Templin, Chairman of the West Coast Public Address and Recording Committee,

had set up and operated the public address equipment built by Fred Whitney, headquarters engineer. Mr. Templin had also arranged to check out all of the sound engineers who were scheduled to operate the equipment during the Convention. Standardized operating techniques were developed and that job was running smoothly for the first time in many years. Messrs. Frayne and Grignon reported upon the work of Grignon's Society Emblem Committee and the Board selected one of three committee recommendations as the final emblem to be worked into the *Journal* cover, stationery, and perhaps lapel pins. The design had been developed by Melvin Stewart, a West Coast design student, and Mr. Grignon was authorized to convey the Board's gratitude for his serious contribution.

NEW SUBSECTION

C. R. Daily, Chairman of the Pacific Coast Section, discussed a request from a number of Society members in the San Francisco area for permission to form a local subsection under the administrative guidance of the existing Pacific Coast Section Board of Managers. P. A. Williams, who served as spokesman for the San Francisco group, had cited the subsection provisions of the IRE constitution and submitted persuasive argument in favor of a parallel organization within this Society. The Board resolved to authorize such a subsection under the proposed arrangement, and Dr. Daily was instructed to advise Mr. Williams and his associates that the Society would support a program of meetings under the Pacific Coast Section Board of Managers.

CONVENTIONS

W. C. Kunzmann, Convention Vice-President, reported that all arrangement for the 70th Convention had been crystallized and that he had made firm commitments for four additional conventions:

71st: Hotel Drake, Chicago, Ill., April 21–25, 1952.

72nd: Hotel Statler, Washington, D.C., October 5–10, 1952.

73rd: Hotel Statler, Los Angeles, Calif., April 26–30, 1953.

74th: Hotel Statler, New York, N.Y., October 1953.

For several years the Board of Governors had considered the merits of replacing the Spring Convention with a series of regional meetings, each of perhaps a day's duration, to be held in areas away from the usual Convention cities and at times when it was unlikely that local people would be attending distant national meetings. The notably successful regional meetings arranged in recent years by the Central Section in Cleveland, Toledo and Detroit were evidence that members in those cities, who are rarely able to attend national conventions, will support occasional meetings "at home." There was extended consideration of *Journal* and Papers complications that might result from such a major change in the Society's convention practices. It had also been suggested that even if the Society were to continue holding two national Conventions each year a series of regional meetings would be of substantial benefit to the Society from a membership standpoint and would also give members in areas where there is considerable motion picture or television activity an opportunity to discuss their mutual problems under professional-technical auspices. No conclusions were reached but the Board will continue to keep a watchful eye on such affairs as the Central Section regional meetings scheduled for Dallas, Texas, on November 7, and for Chicago on November 10.

ELECTIONS

Before concluding the meeting President Mole announced the results of the Society election for 1951. The following officers assume office on January 1, 1952, for a two-year term ending December 31, 1953.

Frank E. Cahill, Jr., Financial Vice-President

Barton Kreuzer, Treasurer

Fred T. Bowditch, Engineering Vice-President

J. E. Aiken, Governor, Atlantic Coast

Axel G. Jensen, Governor, Atlantic Coast

G. W. Colburn, Governor, Central Section

E. W. D'Arcy, Governor, Central Section

F. G. Albin, Governor, Pacific Coast

J. K. Hilliard, Governor, Pacific Coast

Although all section election returns were not completed in time for the Board meeting, the new Boards of Managers were announced subsequently as follows:

Atlantic Coast Section

E. M. Stifle, Chairman, reelected
H. C. Milholland, Secretary-Treasurer, reelected
Frank N. Gillette, Manager 1952–1953
John G. Stott, Manager, 1952–1953
Richard Hodgson, Manager, 1952–1953

Central Section

C. E. Heppberger, Chairman, 1952
James L. Wassell, Secretary, 1952
Kenneth M. Mason, Manager, 1952–1953
James E. Dickert, Manager, 1952–1953
William C. Eddy, Manager, 1952–1953
Reid H. Ray, Manager (appointed to fill out Howard T. Nuttall's term), 1952

Pacific Coast Section

Vaughn C. Shaner, Chairman, 1952
Phillip C. Caldwell, Secretary-Treasurer, 1952
Arthur C. Blaney, Manager, 1952–1953
Linwood G. Dunn, Manager, 1952–1953
Alan M. Gundelfinger, Manager, 1952–1953

Engineering Activities

Six Engineering Committees utilized the recent 70th Convention as a desirable time and place to meet. The highlights of the first three meetings are outlined below; the other three will be described in the next *Journal*.

High-Speed Photography

1. Scope and Name of Committee. Photography has been playing an increasing role in the solution of diverse engineering problems. This fact led the Committee to apply to the Board of Governors for a change in scope (and name) to encompass all such applications. The Chairman advised the group that the request had been rejected to preclude consideration of non-motion picture aspects of photography. It was understood, however, that all engineering uses of motion picture photography, whether high-speed or not, properly fall within the scope of the present committee.

2. West Coast Members. Their problems were discussed at length. These stem from their desire to have the Committee serve a dual function, part Engineering Committee and part Society Section. The suggestion was made that this latter role be correlated with other West Coast Section activity. Arrangements for this have since been made and Roy Wolford has been delegated to work through Charles Daily, Vaughn Shaner and the Section Program Chairman who still is to be appointed.

3. Future Committee Work. It was noted in general terms that a need exists for standards in high-speed photography equipment and that this would be given a high priority at subsequent meetings.

4. Next Symposium. At the Chairman's request Mr. Painter accepted the responsibility for organizing the next symposium at the coming Chicago Convention.

5. New Chairman. Mr. Waddell is to step down at the end of the year, in accordance with requirements of the Bylaws, and at that time a new chairman will be appointed.

Sound

1. Edge Guiding. The recent ballot on revision of PH22.41, PH22.80 and PH22.81 was far from decisive and merely served to emphasize the division existing on the subject. It was felt that the ballot should have contained a more extensive story on the pros and cons of the issue. In addition a fourth alternative was proposed: guide the perforated edge at the picture gate and the sound track edge at the sound head. A Subcommittee was formed, chaired by Malcolm Townsley, to prepare a report of all the factors for use as background material in a new ballot on the question.

2. International Standardization. The group endorsed the program of international standards activity as proposed by Lloyd Goldsmith, Chairman, and Fred Bowditch, Engineering Vice-President.

3. *Nomenclature for Electric Filters, PH22.33-1941.* This was never an American Standard but rather a Recommendation (an ASA classification which no longer exists). The committee was asked to recommend that it be either standardized or dropped. The consensus was that it

was useful at the time of origin but no longer used or needed, and the latter recommendation was voted. The next step is action by the Standards Committee.

4. Magnetic Recording Subcommittee Report. In the absence of Glenn Dimmick, John Frayne made the report. This led to a very broad and thorough discussion on various aspects of magnetic recording and in turn to recommendations to the Subcommittee that it give consideration to a standard for full-width coated 16-mm double-perforated film, additional test films, and striped magnetic film. The Subcommittee was thanked for its excellent work to date.

5. New Test Film Proposed. The need for a scanning illumination intermodulation test film in testing 16-mm projectors was mentioned and concrete proposals for achieving this were agreed on.

6. End of Term. Lloyd Goldsmith is leaving the Chairmanship at the end of the year in accordance with the Bylaw requirements. He thanked the Committee for its fine support these past four years.

Laboratory Practice

1. Negative Cuing Proposal. The Committee has been working on this problem for quite some time and has finally come to the conclusion that the light change cuing device would have to be something other than a notch in the negative if a standard were to be produced. Lloyd Thompson of the Calvin Company has been working on an electrical cuing technique and announced at the meeting that this has been perfected, and is available, patent clear, to the Committee for standardization. This offer was accepted with thanks and plans were made to circularize all committee members and laboratories for comments.

2. 16-Mm Review Room Screen Brightness. After a thorough discussion of the problem and a review of recent survey results it was decided to attempt standardization of the screen brightness of laboratory 16-mm review rooms. A Subcommittee formed previously was asked to draft a proposed standard specifying 14 ft. candles ± some tolerance, use of a white matte screen and the type of meter to be used in making the measurement. This will also be circulated to all committee members and laboratories.

3. Chemical Engineering Abstracts. John Stott, Chairman, called attention to the "Chemical Corner" recently established in the *Journal*, consisting of items and abstracts of interest to laboratories. He praised Irving Ewig for the one-man job he has been doing on this and noted the difficulty of one man continuing the job all alone. He asked all committee members (and any others who may be interested) to send Ewig items of interest from their varied reading, to keep this corner alive.—*Henry Kogel.*

Inter-Society Color Council Meeting

The Inter-Society Color Council is preparing its program for the 1952 Spring meeting to be held February 7–9 at the Statler Hotel in New York. The theme of the meeting is to be "Color in Science, Art, and Industry." The subject matter for the two days is divided between the techniques in the study of color itself, and the various uses color is put to in our time. Some of the topics to be discussed the first morning are, "The Color of Oils," Procter Thomson; "Functional Color," Faber Birren; "Color Reproduction," Arthur C. Hardy; and "Color in Television," Peter C. Goldmark. In the afternoon, Deane B. Judd will report on the ICI meeting at Stockholm; W. D. Wright and Ralph M. Evans, respectively, will discuss "Color in Relation to Vision and to Photography."

The following day such subjects will be discussed as the "Appearances of Color," Harry Helson; "Merchandising of Color," Kenneth C. Welch; "Color in Abstract Movies," A. H. King; "Color for Interiors," Gladys Miller; "Textiles," E. I. Stearns; and "Artists Colors," Martin Fischer. In the evening, I. A. Balinkin will present a special demonstration of "Color Phenomena." At the morning session on February 9 reports of technical committee activities will be received and discussed, and delegates of each of the 21 member associations will summarize their 1951 activities in color.

An exhibit, to be held as a part of this annual meeting, promises considerable interest. Over half of the ISCC's Member Bodies already have agreed to take part, and certain of the technical committees will prepare exhibits relating to their work. By means of these exhibits members may become acquainted with the many prob-

lems and activities of ISCC member associations.

The Nominating Committee of the ISCC has announced the following slate for 1952–53 officers: *Chairman*, E. I. Stearns (AATCC and IMG); *Vice-Chairman*, C. R. Conquergood (NAPIM and IMG); *Secretary*, Dorothy Nickerson (OSA and IMG); *Treasurer*, Norman Macbeth (IES); and *Counsellors*, I. A. Balinkin (outgoing Chairman (ACerS)), Waldron Faulkner (AIA), Gladys Miller (AID), Procter Thomson (AOCS), and Frank J. O'Neil (AATCC and IMG).—*Dorothy Nickerson*, Cotton Branch, PMA, U.S. Dept. Agriculture, Washington 25, D.C.

Book Reviews

Ideas on Film (A Handbook for the 16-Mm Film User)

Edited by Cecile Starr. Published (1951) by Funk & Wagnalls Co., 153 E. 24 St., New York 10. i-xix + 238 pp. + 11 pp. index. 6 × 9 in. Price $4.50.

The main purpose of this volume is to acquaint nontheatrical film users with the problems of production and sponsorship of documentary and educational pictures, and to suggest criteria of choice to the ever-increasing legions of these consumers. Miss Starr, as Nontheatrical Film Editor of the *Saturday Review of Literature*, has used wisely the columns of her magazine to serve precisely that end, and the articles of a score of her distinguished contributors form the body of this intelligent and articulate book.

The multifaceted aspect of the nontheatrical field is examined by such experts as Rudolph Arnheim, Julien Bryan, Kenneth Macgowan, Arthur Meyer, Raymond Spottiswoode, Willard Van Dyke and many others; each in his own sphere scrutinizes the challenge of the "idea" film and discusses its prospect as an expanding factor in our country's intellectual maturing. Miss Starr herself contributes important articles on a variety of subjects, in addition to selecting a list of reviews of some 200 top documentary and educational pictures, and compiling other essential data for the users of 16-mm film.

The foreword, by Irving Jacoby, tackles the basic problem of these films' purpose, which is "essentially to influence what people think." "In these troubled days," writes Mr. Jacoby, "when our freedoms and our dignities are under attack from all sides, we may not at first like the idea of being 'influenced' or even of 'influencing,' for the word carries overtones of violence, expediency, and even contempt for the object that is to be won, changed, and redirected: the human mind." This clear understanding of the nontheatrical film's "propaganda" mission establishes, with eloquence and persuasion, the proper perspective for the whole book.

Miss Starr's collaborators are well aware of this essential nature of their chosen field, and their substantial measure of success in its theoretical and practical manifestations is what makes *Ideas on Film* a valuable and penetrating contribution to our grasp of the complexities of our times.—*George L. George*, Screen Directors Guild, New York.

Fundamentals of Vacuum Tubes

By Austin V. Eastman. Published (1949) by McGraw-Hill, 330 W. 42nd St., New York 18, N.Y. i-xxi + 600 pp. + 30 pp. appendix + 13 pp. index. 460 illus. 6 × 9 in. Price $6.00.

Updating a long-valuable reference and study text, this third edition has revisions occasioned principally by natural advances in electron tubes. In the main, the changes are those which new types have made necessary, and many obsolete tube types have been deleted. Specific improvements over the second edition include a more complete description of the phenomena of current flow through gases, an enlargement to more useful size of many of the charts depicting tube characteristics, and a revised treatment of audio amplifiers to include the concept of gain treated as a vector, taking into consideration the phase angle of the amplifier and its effect on absolute gain and frequency response.

In view of the widespread use of voltage-multiplying circuits in many current

electronic applications, the information on this subject has been enlarged appreciably. A general rearrangement of much of the material provides separate chapters on modulators and demodulators, with much new material on pulse-width, pulse-time, and pulse-amplitude circuits, with a satisfactory analysis of these relatively unfamiliar applications. The material on power series analysis has been expanded into a separate chapter with improved clarity and usefulness.

As in previous editions, the referencing to earlier literature is complete and thorough, making the book one of value to the student as well as to the more advanced reader who may use the volume as a refresher.—*C. G. McProud*, Editor, Audio Engineering, 342 Madison Ave., New York 17, N.Y.

Kino Geraete Technik

By Dr.-Ing. Harald Weise. *In German.* Published (1950) by Akademische Verlagsgesellschaft, Geest & Portig K.-G., Leipzig C 1, Germany. 364 pp. Many schematic and line drawings. 16 pp. supplement of equipment photographs. 6 × 8¼ in. Available in U.S. from Stechert-Hafner, Inc., 31 East 10th St., N.Y. 3. Price $5.00.

It is rare that one encounters a comparative work on mechanism design which manages to present a thorough study of the fundamental kinematics, as well as complete functional descriptions of the equipment. In the German-language volume, *Kino Geraete Technik*, the designer of motion picture apparatus is fortunate in finding just such a work.

This is the first part of a proposed two-volume set on substandard (8-mm and 16-mm) motion picture equipment, of which the volume here reviewed deals with cameras. Volume 2 will deal with projection apparatus. The author says in his foreword that additional similar works on theatrical (35-mm) and still equipment are in preparation.

Anyone familiar with the problems of optical and mechanical mechanism design is likely to be awed by the painstaking detail with which each component of the many makes of equipment has been analyzed. The author has reduced to their fundamental principles film drives, intermittent movements, film paths, registration devices, mirror and prism systems, shutters, motors, governors, counters, magazines, etc. The task seems all the more impressive when one notes the author's statement that his data were derived primarily from sample units, photographs, catalogs, and technical papers, and only in rare instances from manufacturers' drawings. Thus the book is truly a monumental achievement in careful measurement and analysis.

It is this exceptional accuracy, and the care taken to preserve correct proportions and "unitless" diagrams, which make *Kino Geraete Technik* so valuable to the motion picture equipment designer. In addition, manufacturers and personnel utilizing motion picture apparatus in research work and photographic instrumentation will be able to gain much qualitative and quantitative information from this book.

From its early chapters on the basic physical and physiological factors of the motion picture medium, right through its exhaustive bibliography and pictorial supplement, the work is clearly and concisely written, and liberally illustrated with diagrams and graphs. An effort has been made to trace the historical evolution of many of the mechanisms, giving an insight into the trial-and-error progress of the art, and pointing the way toward future development.—*Peter V. Norden*, J. A. Maurer, Inc., 37–01 31st St., Long Island City 1, N.Y.

Journal indexes covering the thirty-four years from 1916 through 1950 may be purchased from Society Headquarters.

1916–1930 $1.25 1930–1935 $1.25 1936–1945 $2.00 1946–1950 $1.50

SMPTE Officers and Committees: The roster of Society Officers and the Committee Chairmen and Members were published in the April *Journal*.

Style and the Journal

Style is a small but important aspect of editing this *Journal*. The staff is preparing a Style Manual for which suggestions are welcomed from contributors to, as well as readers of, the *Journal*.

The Style Manual will contain the usual specifications and advice for the physical arrangement, organization and presentation of Society papers, which are aspects currently being very well accomplished by most authors for the *Journal*.

This *Journal*, like all periodicals, is copy-edited in accordance with chosen rules of spelling, punctuation and abbreviation. These rules and lists of examples will make up a large portion of the Style Manual. The Editor would like to hear from any readers who have pet peeves or favorites in matters of style.

The *Journal's* style is being continually evolved on the basis of experience with the *Journal's* own subject matter. The style does, however, generally follow these standard reference works: the *Merriam-Webster Dictionary*, the American Standards Association's "Abbreviations for Scientific and Engineering Terms, ASA Z10.1–1941," the American Institute of Physics' "Style Manual," the American Chemical Society's "List of Periodicals," "Subject Index," and its "Directions for Assistant Editors and Abstractors of Chemical Abstracts."

The *Merriam-Webster Dictionary* covers a surprisingly large number of points of style in motion picture and other technical terminology, a few examples of which are: by-pass, cutoff (as noun), disk, infrared, nonlinear, selsyn and theater. We cannot, however, always follow the dictionary because the dictionary is a reference of recorded usage and we must often lead in establishing usage. The Style Manual will list deviations such as the following: blackbody, overall, peephole, viewfinder and wavelength.

Abbreviations are used whenever it is believed they make reading easier and faster for the average reader. The abbreviations are almost always those in ASA Z10.1–1941, although that document is not always the last word since it is now ten years old. For instance, ASA gives megacycle spelled out; we use mc. Not so readily resolved is the abbreviating of cycles per second. ASA shows "spell out or use c"; the American Institute of Physics says abbreviate as cps. Using c or cps would appear logical, but in the *Journal* we often have the term frames per second, which cannot become fps because that stands for feet per second; therefore the *Journal* now uses cycle/sec and frame/sec, although in simple references it is acceptable to say 60-cycle power rather than 60-cycle/sec power.

The *Journal* now uses the abbreviations 16-mm and 35-mm in text and 16-Mm and 35-Mm in display lines. There are many variations current and it seems time to adopt one which is especially suited to our field — 16mm and 35mm. This seems less appropriate for 8mm, 17½mm and 32mm, but for the sake of consistency they should also be used. It is felt that 16mm and 35mm are customary enough so that the extended usage will read easily and not obtrude on the reader.

The brief exposition above has been put as impersonally as possible because the parts of style dealt with are those few matters which must be consistent throughout the publication and cannot be left to the personal choice of *Journal* writers; however, particularly at this time, any expression of personal preferences and the reasons therefor, on any points of copy-editing style, will be welcomed. Also, please advise the Editor whether you would be willing to review parts of the Style Manual if it were mimeographed for circulation and comment.

While we are crystallizing these details, the editorial policy will continue to be that of adhering to as much of each author's individual style as will not seriously detract from the efficient reading and enjoyment of his paper. Indeed, there is now in process a paper which will probably be published with the pronoun "I" sprinkled throughout. We are not going to rewrite or revamp papers so that they all read alike in the *Journal*.

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1950 MEMBERSHIP DIRECTORY.

Honorary (**H**) Fellow (**F**) Active (**M**) Associate (**A**) Student (**S**)

Ahern, William R., Lighting Director, National Broadcasting Co. **Mail:** 63 Laurel St., Floral Park, Long Island, N.Y. (**M**)

Atchley, Dana W., Jr., Engineer, United Paramount Theatres, Inc. **Mail:** 6 Chandler St., Lexington, Mass. (**M**)

Baker, C. T., Jr., Presbyterian Minister, Visual Aids Producer. **Mail:** 1122 Greenfield Ave., Nashville, Tenn. (**A**)

Barragan, R. W., Engineer. **Mail:** 1043 Park, El Centro, Calif. (**A**)

Betts, Howard B., Vice-President, Optomechanisms, Inc. **Mail:** 1079 E. 28 St., Brooklyn 10, N.Y. (**M**)

Boggs, Chester A., Engineer, Century Engineering, Inc. **Mail:** 1938 Mill Rd., South Pasadena, Calif. (**M**)

Boots, Paul K., School of Radio Technique. **Mail:** West Side YMCA, 5 West 63 St., New York 23, N.Y. (**S**)

Boylan, Edward M., Sensitometrist, U.S. Army (Reserve—Active Duty). **Mail:** 44 Holden St., Rochester, N.Y. (**M**)

Coleman, R. E., Manager, Kearse Theatre. **Mail:** PO Box 1133, Charleston 23, W.Va. (**M**)

Dula, Arthur M., Photographic Engineer, Engineering and Technical Div., Signal Corps. **Mail:** 505 East Westmoreland Rd., Falls Church, Va. (**A**)

Duncan, Charles B., Sound Engineer, Standard Theatre Supply Co. **Mail:** 219 South Church St., Charlotte, N.C. (**M**)

Golan, Joseph C., Superintendent, Production, Eastman Kodak Co. **Mail:** Huntington Hills, Rochester 9, N.Y. (**M**)

Gordon, Alan, Designer and manufacturer of photogrammetric equipment, Gordon Enterprises. **Mail:** 5362 North Cahuenga Blvd., North Hollywood, Calif. (**M**)

Hockman, Lt. Charles N., Director, Motion Picture Unit, University of Oklahoma. **Mail:** 2d Photographic Sq., c/o 548 Recon. Tech. Sq., APO 328, c/o PM, San Francisco, Calif. (**M**)

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Chemical Corner

Edited by Irving M. Ewig for the Society's Laboratory Practice Committee. Suggestions should be sent to Society headquarters marked for the attention of Mr. Ewig. Neither the Society nor the Editor assumes any responsibility for the validity of the statements contained in this column. They are intended as suggestions for further investigation by interested persons.

Chamois Fabric "X-Lint" is a fabric impregnated with "Hycar" latex which has all the properties of chamois but wears longer and, the manufacturer states, is unaffected by chemicals ordinarily harmful to chamois. "X-Lint" does not have the ragged ends and thin spots of chamois. The manufacturer of this product is Loren Products Corp., 101 West 31st St., N.Y. 1, N.Y.

New Idea in Filter Cloths Dynel filter cloths are made of acrylic fibers and are claimed to be superior to most filter materials because they are supposed to have good dimensional stability, are mildew-proof, easy to clean and nonblinding. Inquiries are directed to The Filtration Engineers, Inc., Newark, N. J.

Task of Making Fixer Greatly Simplified The L. B. Russell Chemicals, Inc., 60 Orange St., Bloomfield, N.J., manufactures a single powder which, when dissolved in water, forms a complete, odorless acetic-acid, long-lasting fixer. This preparation is called Super-Fix. The company states that film processed in this fixer will wash easily because of the proper adjustment of the pH and will have a well-hardened emulsion. Furthermore, the hypo which is used here is dehydrated, resulting in great reduction of bulk. This fixer powder eliminates the use of hypo crystals, acetic acid and all the other heavy fixer chemicals. This should be of interest to the smaller laboratory.

Floor Refinishing "Plastic Rock" makes a perfectly new, durable floor in forty-eight hours. It bonds well to concrete, wood and steel. It also is slipproof and fire resistant. The vendor is United Laboratories, 16801 Euclid Ave., Cleveland, Ohio.

Insect and Pest Control U.S. Industrial Chemicals has developed a new type of insecticide during World War II which they call "Lindane." It is claimed to be one of the most effective modern chemical insecticides. "Lindane" is effective against a wide variety of insects and is harmless to humans. The address of the manufacturer is 60 E. 42 St., New York 17, N.Y.

Corrosion-Proofing With a New Galvanizing Compound "Zinc-Rech" cold galvanizing compound produces an electrochemical reaction which deposits zinc on steel or iron surfaces, thereby galvanizing them. It can be applied by dip, spray or brush. Inquiries are directed to The Chase Chemical Co., 40 W. 29 St., N.Y. 1, N.Y.

Motion Picture Film and the Weather In the *Heating, Piping and Air-Conditioning Journal*, vol. 22, H. C. Brush, in his article "How humidity and temperature affect motion picture film," describes some interesting relations between temperature and relative humidity and various physical properties of film such as buckle, curl, shrinkage and brittleness. The influence of the atmospheric conditions on dust control, static, and storage of film is also considered.

New Idea for a Small-Capacity Water Filter A small water filter employing anthracite coal as a filtering medium is described in an article, "Fotopak water filter for finishers," in *Photo Developments*, vol. 24. The unit has a capacity of 100 gal/min, and no filter cones are needed.

Dye-Coupling Developers as Toners Since the use of uranium nitrate for the toning of motion picture film has been discontinued, it is difficult to duplicate the color with other toners. It is possible now, however, to achieve similar, and perhaps an even wider range of, tones by the use of dye-coupler developers. In this process the highlights are left entirely free of stain. The method is described in *The Photo Lab Index* as well as in many other such reference books. The chemicals are obtainable from The Eastman Kodak Co., Rochester 4, N.Y. The F. R. Corp. has marketed such a toner-developer under the name of "Develochrome." It is described in *Photo Trade News*, vol. 14, Sept. 1951, in an article by G. Steans.

Keep Out the Fire Weldwood Fire Doors have good insulating qualities for maintaining low temperatures in the protected areas. In a recent test the temperature of an exposed face of Weldwood Fire Door stayed down to less than 400 F after a 1-hr exposure to flame compared to 1000 F and 800 F for other fireproof doors. This product is marketed by U. S. Plywood Corp., 55 W. 44 St., New York 18, N.Y.

Watch Out for Old Film Valuable data on the subject of the composition and combustibility of nitrate film is discussed in the article "The anatomy of nitrocellulose film," by R. A. Mitchell and published in *The International Projectionist*, Feb. 1948. When nitrocellulose film decomposes it gives off gases which are inflammable and are the cause of so-called celluloid explosions. The emulsion helps somewhat to slow down the combustion. The emulsion leaves a black ash and gives off harmful fumes.

Temperature Control Device for Experimental Darkroom Hanney and Waldram, in an article, "Controlled temperature equipment for the experimental darkroom," in *The Photographic Journal, Section B*, July-August 1951, describe a thermostatically controlled water bath which keeps solution bottles at a temperature of 0.2° and which maintains a stainless-steel developing dish at the same temperature by a water jacket. Safety devices are also described for the protection of the equipment which is left unattended.

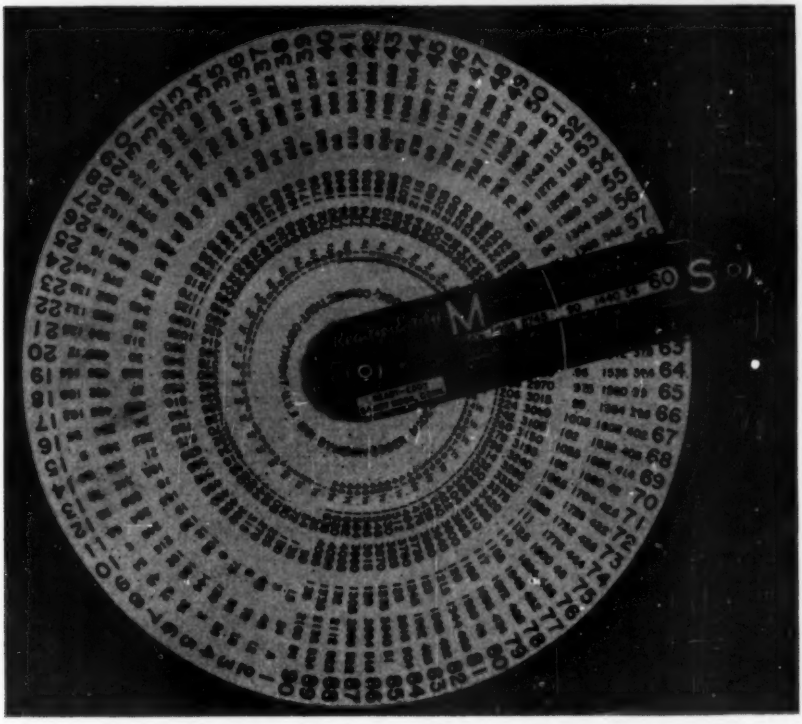
Back Issues of the Journal Available

The issues of May 1946, August 1946, February–July 1947 and September 1947 to date are available at $0.75 per copy from Robert G. Ellhamer, Box 2549, Hollywood Station, Los Angeles 28, Calif.

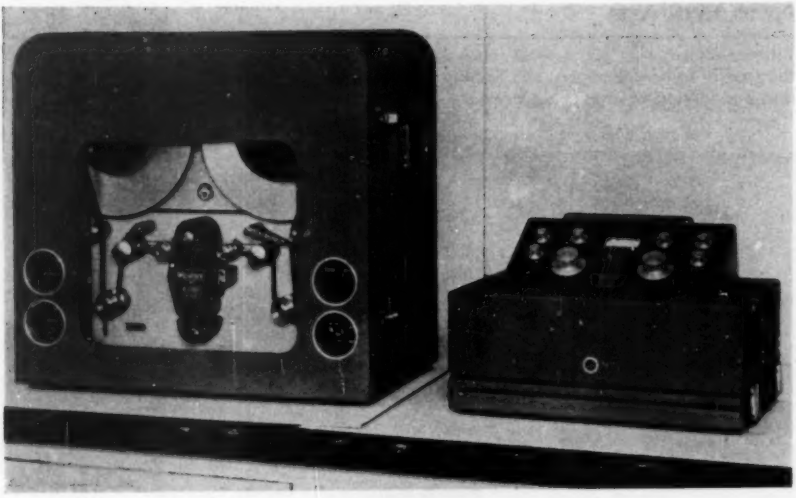
A set of Journals from October 1938 to the present date, except for the June 1939 issue, is available at $75.00 for the lot, from Harry Hollander, 21-36—77th St., Jackson Heights, L.I., N.Y.

New Products

Further information about these items can be obtained from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of news items does not constitute an endorsement.



Ready-Eddy is the name given a new computer for sound film editors by its inventor, Henry Roger of Sandy Hook, Conn. It provides, with a turn of the wheel, correlated data regarding footage, projection time in seconds and minutes, number of frames per foot and per second, and equivalents of 16-mm and 35-mm film. One side of Ready-Eddy shows an "F" scale, representing feet, on the circumference of the disk, with four inner bands, two indicating seconds and number of frames for 35-mm film and the next two indicating the same for 16-mm film. The opposite side of the disk has two scales for time. On the periphery, "S" for seconds relates to three adjoining bands indicating feet of 16-mm film, number of frames of both 16-mm and 35-mm film (in this case the same for both) and feet of 35-mm film. Scale "M" for minutes starts from the inside and is subdivided into half-minutes of projection time. The two adjacent bands indicate the equivalent footages of 16-mm and 35-mm film, for from 1 to 45½ min. The inventor expects Ready-Eddy to be handy for television as well as motion picture editors. It is pocket-size, made of plastic, and costs $2.00. A plastic carrying case is $.50 extra.



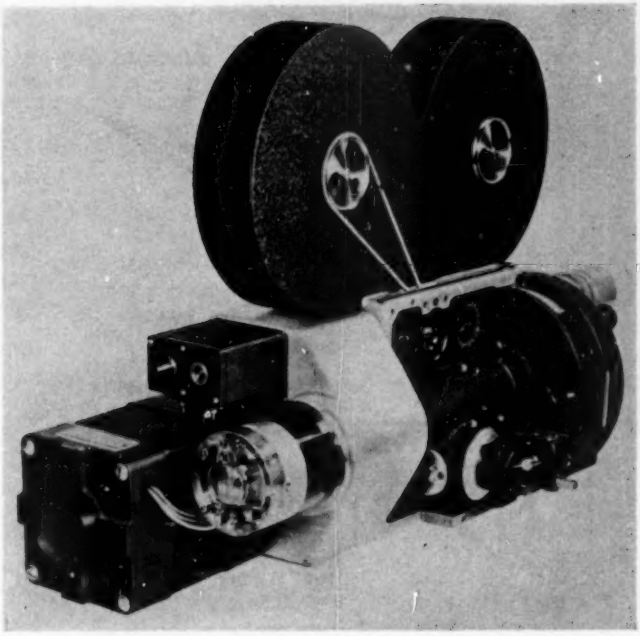
The 1000 Series Portable Magnetic System now being introduced to the industry is a direct outgrowth of field experience with the earlier 1000 Series System previously described in the *Journal* for March 1951. The number of cases has been reduced to two as shown in the photograph, the two-position mixer being on the right and the recorder being on the left. The latter houses, in addition to the film pulling mechanism, the a-c power supply for the channel, the bias oscillator and the film monitor amplifier.

New features of this system include two-way talkback equipment between the mixer and recordist, a talkback amplifier being provided in the recorder housing. Another new feature is a synchronizing bloop unit which records an audible signal when the recorder is up to speed on the magnetic film in synchronism with an optical bloop in the associated photographic camera.

The system operates from 115 v, single-phase, 50- or 60-cycle a-c supply, provision being also made for motor operation from 220 v, 3-phase, interlock or multi-duty motor systems. Runback at normal speed is provided. The power drain for the electronic components is somewhat less than 100 w and a 2-amp drain at 115 v is required for the single phase motor supply.

The weight of the complete system, including cables, is approximately 170 lb. The system is available for 35-, 17½- or 16-mm operation. The track positions are in accordance with the proposed ASA magnetic track standards for 35- and 16-mm films. The recorder may also be used as a magnetic film reproducer, equalization being provided in the playback amplifier to give an essentially flat response from 50 to 8000 cycles when operating at 90 ft/min. By incorporating some pre-emphasis in recording on 16-mm film, a flat response to 6000 cycles may be obtained at the 16-mm speed of 36 ft/min.

Your Journals bound make a valuable permanent reference. Six issues constitute a Volume and should be bound with the special contents page (supplied beginning with Vol. 56) and index furnished with each June and December issue. For details of binding see page 702 of the June 1951 *Journal*.



The Maurer Servo-Sync Camera Drive, a new system for synchronized motion picture camera operation, providing greatly closer time synchronization than heretofore possible, is announced by J. A. Maurer, Inc., Long Island City, N.Y.

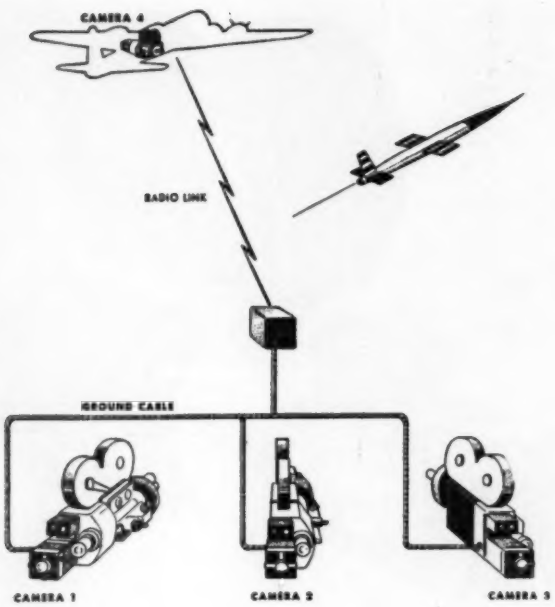
The system, known as the Maurer Servo-Sync Camera Drive System, was designed by Origins, Inc., Saybrook, Conn., and is manufactured by J. A. Maurer, Inc. It is designed to achieve a long-sought goal in scientific photography—dependable, consistent, and accurate operation of a series of motion picture cameras taking their pictures at the same time to close tolerance. Maximum possible deviation of shutter position in this system, which utilizes circular rotating camera shutters, is less than 1°, which at 12 frame/sec is equivalent to an accuracy of 23 microseconds. (A microsecond is one-millionth of a second.) As frame frequency increases, the angular accuracy remains essentially unchanged, while the time accuracy decreases. For example, at 50 frame/sec, the angular deviation is still approximately 1° and the time accuracy has increased to a maximum deviation of 35 microseconds. Due to the nature of the continuously rotating system, failures common to pulse-operated systems are eliminated. Patent rights are reserved.

The Servo-Sync Camera Drive System has been applied to a 35-mm motion picture camera of standard manufacture which uses interchangeable magazines having capacities of 400 and 1000 ft of film. The system is not limited to one camera type but is equally applicable for use with a large number of motion picture, scientific, and ribbon-frame cameras, and motion picture and process projectors.

The 35-mm camera system was developed for the Wollensack Optical Co., Rochester, N.Y.

Among the scientific and engineering applications for which this system will be utilized are: data recording, flight testing, missile tracking, ordnance evaluation, and most applications where two or more sources of information must be recorded at essentially the same time.

There is no practical limit to the number of cameras (projectors) that may be



synchronized by this method. An interesting use lies in three-dimensional studies where two geometrically oriented cameras are required for simultaneous recording. The system also has application in professional and television motion picture production where extremely close time synchronization of a number of cameras, projectors, or sound recording apparatus is required.

Statement of the Ownership, Management, and Circulation Required by the Act of Congress of August 24, 1912, as Amended by the Acts of March 3, 1933, and July 2, 1946 (Title 39, United States Code, Section 233), of *Journal of the Society of Motion Picture and Television Engineers*, published monthly at Easton, Pa., for October, 1951.

1. The names and addresses of the publisher, editor, managing editor, and business managers are:
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Managing editor, None.
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VICTOR H. ALLEN, Editor.

Sworn to and subscribed before me this 17th day of September, 1951.

[SEAL] A. Ruth McCarthy
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(My commission expires in New York County, March 30 1952)

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